Marconi
Instruments

OSCILLOSCOPE

TF 2210

Instruction Manual
No. EB 2210
for

Oscilloscope TF 2210

mi
Technical Publications

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MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND

Contents

Chapter 1 GENERAL INFORMATION

1.1 Introduction 3
1.2 Data summary 4
1.3 Accessories 7

Chapter 2 OPERATION

2.1 Preparation for use 8
2.2 Power supply 8
2.3 Controls 8
2.4 First time operation 10
2.5 Use of delaying sweep 12
Variable delay - normal sweep mode 12
Variable delay - dual sweep mode 12
Triggered delay - normal sweep mode 13
Triggered delay - dual sweep mode 14
2.6 Single sweep operation 15

Chapter 3 TECHNICAL DESCRIPTION

3.1 Trigger circuits 16
Basic system - board A12 ... 16
Circuit analysis - board A12 ... 16
3.2 Sweep function synopses 17
A sweep normal 17
B sweep normal 19
Alternate sweeps 19
Delaying sweep: variable ... 20
Delayed sweep: variable ... 21
Variable delay sweeps: alternate .. 21
Triggered delayed sweeps ... 22
3.3 Dual sweep function 23
3.4 Single sweep function 23
3.5 Sweep circuit analyses 24
Board A10 24
Board A11 25
Board A14 26
Board A16 28
Board A17 28
Board A18 29
3.6 Horizontal amplifier 29
3.7 Calibrator and supply light control. 30
Board A19 30
3.8 Cathode ray tube circuitry ... 30
Board A1 30
3.9 Vertical delay 31
Board A3 31
3.10 Power supply 31
Basic system 31
Board A4 and Unit A5 31
Board A6 31
3.11 E.H.T. 32
Basic system 32
Unit A2 32

Chapter 4 MAINTENANCE

4.1 Introduction 34
4.2 Screw fasteners.. 34
4.3 Access and removal of units ... 34
4.4 Test points 35
4.5 Location of sub-assemblies ... 35
Annotated layout illustrations ... 36
4.6 Performance checks 39
4.7 Cleaning and lubricating 42

Chapter 5 REPAIR

5.1 Introduction 43
5.2 Component location 43
Printed board illustrations ... 43
5.3 Replacement of components ... 43
5.4 Fault finding 47
5.5 Realignment 53

Index to Units 61

Chapter 6 REPLACEABLE PARTS

Introduction and ordering 62
Parts lists - (see Index on page 61)

Chapter 7 CIRCUIT DIAGRAMS

Circuit notes 80

Fig.
7.1 A0 : A3 General interconnection diagram 81
7.2 A1 : A2 E.H.T. unblanking and c.r.t. circuits 83
7.3 A4 : A5 Power unit wiring ... 85
7.4 A6 Regulator unit 87
7.5 A7 A sweep interconnecting diagram 89
7.6 A8 B sweep interconnecting diagram 91
7.7 A9 : A18 Single sweep unit ... 93
7.8 A10 : A17 A and B unblanking; A single sweep circuit and B high level sweep gates 95
7.9 A11 Delay pick-off; switching and alternative bistables 97
7.10 A12 : A15 Trigger circuits and TIME/CM switch 99
7.11 A13 : A19 Horizontal amplifier, calibrator and supply light indicator 101
7.12 A14 : A16 Sweep and trigger gate circuits 103

Chapter 1

General information

1.1 INTRODUCTION

The fully transistorized TF 2210 Oscilloscope is a wide range general purpose laboratory instrument for precision measurement of high speed phenomena. The triggered horizontal deflection can be accurately delayed, enabling detailed observation, photography and measurement of selected portions of complex waveforms. Such displays are possible by the fast rise time combined with wide sweep-speed range of this oscilloscope. A full 6 cm display is available throughout the frequency range and the 13.5 kV post deflection accelerating voltage ensures adequate intensity of high velocity sweeps.

The instrument is provided with a dual trace plug-in allowing a signal to be connected in a cascade arrangement which gives a sensitivity of up to 500 μV/cm with a reduced bandwidth.

In addition to its many uses as a general purpose high quality oscilloscope, the TF 2210 has the advantages of a delayed sweep, so that any portion of a complex waveform may be greatly enlarged and presented as a jitter-free image for precise analysis. Special circuits incorporated in the A sweep unit, allow accurate triggered or continuously variable delay in the presentation of a sweep from 0.5 μsec to 10 sec.

Single sweep operation can be used for photographing 'once only' phenomena, or for photographing spurious signals in a recurrent waveform. The oscilloscope was supplied with either A and B sweep units or with a B sweep unit and a single sweep unit. However, the single sweep unit, TM 9219, is no longer available and the corresponding information included in this manual is for reference purposes only. The facility of single sweep continues to be provided with the A sweep unit.

The TF 2210 has a power supply unit that is well protected, and a visual front panel indication of the supply voltage. The POWER ON light flashes at a fast rate if the supply voltage is > 10% high, and at a slow rate if > 10% low. A wide range of accessories is provided which expands the versatility and practical uses of the instrument.

Fig. 1.1 Oscilloscope TF 2210 with dual trace plug-in unit

1.2 DATA SUMMARY

Cathode ray tube	Philips D13 450GH/03 with P31 phosphor and internal graticule.
Display area:	6 cm x 10 cm.
Trace locate:	The TRACE FINDER button brings the trace into the window for all positions of the shift controls and causes the time base to free-run.
Vertical plate sensitivity:	Nominally 3 V/cm.
Horizontal plate sensitivity:	Nominally 10 V/cm.
Z modulation:	Requires positive-going current pulses of 5 mA p-p into 50 Ω to increase trace brightness. Bandwidth from d.c. to 10 MHz.
Calibration unit	Available at front panel loop marked CALIBRATOR.
Square wave:	3 V p-p ±1% at 1 kHz from a source impedance of 500 Ω.
Switched current:	6 mA p-p ±1% at 1 kHz.
Vertical amplifier	See Y plug-in manual.
Horizontal amplifier	
Magnifier:	Three switched ranges, x1, x5 and x10, extending the fastest sweep range to 5 ns/cm.
External horizontal magnifier:	Three switched ranges, x1, x5 and x10, giving a sensitivity of 1 V/cm, 0.2 V/cm and 0.1 V/cm.
Bandwidth:	From d.c. to 5 MHz (typically).
Accuracy:	±3%.
Input impedance:	Approximately 10 kΩ shunted by approximately 60 pF.
Maximum input voltage:	40 V combined d.c. and a.c. peak.
Horizontal positioning controls:	Coarse: typically ±9 cm of control. Fine: typically ±0.9 cm of control.
Delayed sweep (B)	
Sweep rate:	Twenty-three switched ranges in 1:2:5 sequence covering the range 50 ns/cm to 1 s/cm.
Variable sweep rate:	Uncalibrated control gives a velocity of up to 2.5:1. The indicator light shows when the time base is being operated in an uncalibrated condition.
Overall accuracy:	±3%.
Trace length:	Nominally 7 to 13 cm.

Trigger modes:	AUTO:	50 Hz to 10 MHz from a 4 mm display, degrading to 1 cm at 100 MHz.
	DC coupled:	d. c. to 10 MHz from a 3 mm display, degrading to 1 cm at 40 MHz.
	AC coupled:	20 Hz to 10 MHz from a 3 mm display, degrading to 1 cm at 40 MHz.
Trigger source:	INTernal:	positive or negative.
	EXTernal:	positive or negative.
	LINE:	positive or negative.

External trigger

Sensitivity:	As for internal trigger modes if 25 mV p-p is substituted for each 1 mm of display.
Input impedance:	1 MΩ shunted by 25 pF.
Maximum input voltage:	500 V.
Trigger level:	Internal window approximately 12 cm. External window approximately 3 V.
Sweep output:	Positive-going with respect to earth.
Amplitude:	4 V p-p nominal (for a 10 cm trace).
Output resistance:	< 500 Ω.
Gate output:	Positive with respect to earth.
Amplitude:	4.5 V p-p nominal.
Output resistance:	< 250 Ω.

Delaying sweep (A)

Sweep display modes:	Three switches, each with three positions, give the following sweep display combinations:
Normal:	(A)+(B): (A) sweep is triggered by the signal. (+B) is only operative on delay positions. (B) only: (B) sweep is triggered by the signal. ALT: (A) and (B) sweeps alternately displayed.
Variable delay:	(A)+(B): The delaying sweep, (A), is triggered by the signal and, after an adjustable delay, triggers the main sweep (B). The brightened portion of the sweep indicates the position and duration of the delayed sweep (the position being adjustable to the left or right by the delay time multiplier). (B) delayed: This expands the brightened portion of the sweep (as displayed in the (A)+(B) mode of operation) to the full width of the c. r. t. ALT: (A)+(B) and (B) delayed modes displayed alternately.
Triggered delay:	(A)+(B): The delaying sweep (A) is triggered by the signal and, after an adjustable delay, opens a gate which allows the main sweep (B), to be triggered. The brightened portions of the sweep indicate the position and duration of the (B) sweep. The gate is closed after one sweep of the main sweep.

(B) delayed: This expands the brightened portion of the sweep (as displayed in the (A)+(B) mode of operation), to the full width of the c.r.t.
ALT: (A)+(B) and (B) delayed modes displayed alternately.

Dual triggering

Variable delay:

(A)+(B): The delaying sweep (A) is triggered by the signal. Sweep (B) is triggered twice, first undelayed and coincident with the start of the (A) sweep, and secondly after an adjustable delay. The brightened portions of the sweep indicate the position and duration of the (B) sweeps (the position of the delayed (B) sweep being adjustable by the delay time multiplier).
(B) delayed: This expands both of the brightened portions of the sweep (as displayed in the (A)+(B) mode of operation) to the full width of the c.r.t. hence signals on the (B) sweep may be superimposed.
ALT: (A)+(B) and (B) delayed modes displayed alternately.

Triggered delay:

(A)+(B): The delaying sweep (A) is triggered by the signal. Sweep (B) is triggered twice, first undelayed and coincident with the start of the (A) sweep, and secondly after an adjustable delay opens a gate which allows the delayed sweep (B) to be triggered. The brightened portions of the sweep indicate the position and duration of the (B) sweeps (the position of the delayed (B) sweep being adjustable by the delay time multiplier).
(B) delayed: This expands both of the brightened portions of the sweep (as displayed in the (A)+(B) mode of operation) to the full width of the c.r.t. hence signals on the (B) sweep may be superimposed.
ALT: (A)+(B) and (B) delayed modes displayed alternately.

Sweep delay: 0.05μs to 10 sec continuously variable with the CM DELAY control.

Sweep delay accuracy: ±2% (+100 ns fixed delay).

Sweep delay jitter: Better than 1 part in 20 000 of maximum delay.

Single sweep: A three-position switch having NORMal, DUAL TRIGger and SINGLE SWEEP positions, permits single shot operation on all sweep display modes except ALTernate.

Power requirements

200 to 250 V or 100 to 130 V a.c. 45 Hz to 500 Hz.

Power consumption: 180 VA.

Overload protection: All regulated lines are overload protected.

Dimensions and weight

Height	*Width*	*Depth*	*Weight*
13 in (325 mm)	9 in (225 mm)	21.5 in (538 mm)	49.5 lb (22.5 kg)

1.3 ACCESSORIES

Supplied

Green Filter B37533-710 and Rubber Mask mi 37186-105.
Two 2 mm Belling Lee (black) plugs 23431-057.
Two 2 mm Belling Lee (red) plugs 23421-056.

Optional

x1 x10 Attenuator Probe 54721-021.
Passive Probe x100, 54451-021 (suitable for use with 54721-021).
Graticule Projector TM 8098.
Oscilloscope Trolley TM 7424/M1.
Mini-trolley TM 8550/M1.
Polarizing Filter TM 7991.
Extension cables for servicing plug-in units.
Viewing Hood TD43245.

Chapter 2

Operation

2.1 PREPARATION FOR USE

The instrument is provided with a mains lead wired into the rear panel. The customer should provide a mains plug suitable for connection to a convenient power socket. The mains lead is colour coded as follows:

Blue	-	neutral
Brown	-	live
Green/yellow	-	earth

Ensure that the voltage selection panel (located on the rear panel) is set to the correct voltage for your power supply, see the following section.

CAUTION

Do not obstruct the ventilation of this instrument particularly underneath the oscilloscope between the runners, and also the rear flanged panel which constitutes a heat sink for the power unit.

The oscilloscope is provided with a tilt stand for ease of operation.

2.2 POWER SUPPLY

The voltage selection panel, located on the rear panel, should be set as follows. Remove the bar plug and insert in the socket panel so that the arrow points to the correct mains supply, see Fig. 2.1. Normally the instrument is dispatched to you with the voltage set to 240 V a.c.

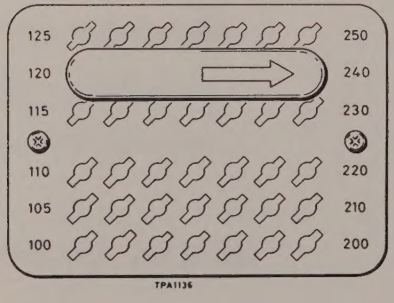


Fig. 2.1 Voltage selection panel

When the POWER is turned ON the green light should glow steadily. If the light flashes at a slow rate, then the supply voltage is more than 10% lower than that set on the selection panel; if the light flashes at a high rate, then the supply voltage is more than 10% higher than that set on the selection panel.

2.3 CONTROLS

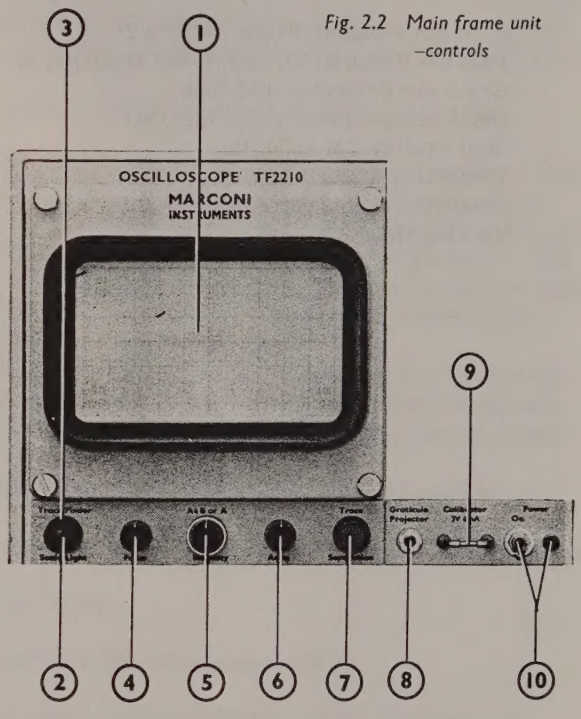


Fig. 2.2 Main frame unit –controls

Main frame unit

① C.R.T. Provides a 10 x 6 cm display area with internal graticule.

② TRACE FINDER: This push button reduces the horizontal and vertical amplifier windows so that any signal will always be displayed on the screen regardless of the positions of vertical and horizontal controls. When there is no signal applied, a base line trace from the free running time bases will appear when the button is pressed.

③ SCALE LIGHT: Variable control which adjusts the graticule illumination.

④ FOCUS: Adjusted in conjunction with ⑥ to obtain the sharpest spot at the given sweep velocity in use at the time.

⑤ A & B or A INTENSITY: The knurled metal control adjusts the intensity of the A sweep only, and the red concentric control adjusts the intensity of the A & B sweeps simultaneously.

⑥ ASTIG: See ④.

⑦ TRACE SEPARATION: Permits the two horizontal displays of the same signal to be separated in the vertical direction so that they may be viewed more easily when the time base is in one of its alternate modes.

⑧ PROJECTOR jack: Allows the standard mi Graticule Projector, TM 8098, to be used in conjunction with this oscilloscope.

⑨ CALIBRATOR bar: A 3 V ±1%, 1 kHz square wave signal and a 6 mA 1 kHz square wave current signal are permanently present in this bar. Hence current probes at 6 mA p-p and 10:1 divider probes at 3 V p-p at minimum attenuation may be calibrated by direct connection to it.

⑩ POWER ON switch and light: See Sect. 2.2.

A and B sweep units

⑪ TIME/CM switch: This twenty-three position switch gives a choice of sweep velocities from 50 ns/cm to 1 s/cm.

⑫ VARIABLE TIME/CM: Concentric with ⑪, this control gives at least 2.5:1 reduction of velocity on all ranges.

⑬ UNCAL light: Will glow when ⑫ is in an uncalibrated position.

Fig. 2.3 A and B sweep units—controls

⑭ CM DELAY: 10-turn potentiometer enabling the delayed point on the screen to be set accurately between the limits of 0.5 and 10 cm of display.

⑮ GATE OUT: A positive-going rectangular signal of about 4 V nominal amplitude appears on this socket corresponding to the bright-up signal fed to the grid of the c.r.t.

⑯ LENGTH: This preset, next to the TIME/CM switch, enables you to set the trace length between 8 and 12 cm.

⑰ SWEEP OUT: Carries a positive-going sawtooth waveform of 4 V nominal amplitude, corresponding to the deflection signal applied to the horizontal deflection plates of the c.r.t.

⑱ SWEEP switch: Provides either normal or dual sweep and a single sweep facility.

⑲ DELAY switch: Selects VARiable or TRIGgered delay modes. For normal operation, set to the OFF position.

⑳ DISPLAY switch: Selects the desired sweep to be viewed. In the A+B position, the B Sweep will be seen as a brightened portion on the A Sweep, except when the DELAY switch is in the OFF position, when the A sweep only will be displayed.

㉑ RESET: This control is used in the single sweep mode. The light indicates the state of the single sweep facility and the RESET button arms the bistable circuit which controls the single sweep action, i.e. when the light is on the sweep is ready to be triggered.

Horizontal amplifier

㉒ ㉓ Coarse and FINE POSITION: Coarse and fine adjustment capable of moving a trace to either side of the screen.

㉔ x1 - x5 - x10: Increases the fastest sweep velocity to 5 ns/cm.

㉕ MAG light: In the x5 and x10 position of ㉔ this light will glow.

㉖ INPUT socket: Enables the horizontal amplifier to be used as a separate entity. The trigger source must be put to EXTernal or the triggering source removed by some means; then the signal at the INPUT socket can be used to deflect the screen trace horizontally. Maximum input 40 V combined a.c. and d.c. p-p.

NOTE: This BNC socket is always in circuit and any signals applied will be added to the sweep already being generated.

Trigger controls

㉗ AUTO - DC - AC: Selects the trigger mode for the appropriate sweep unit allowing automatic, a.c. or d.c. coupled triggering.

㉘ SLOPE switch: The + - signs correspond to the polarity of display or to the slope or direction of the signal on the left-hand side of the screen.

㉙ SOURCE switch: Provides a choice of triggering from INTernal or from EXTernal. In the LINE position, triggering will be at supply frequency.

㉚ LEVEL control: In the A.C. and D.C. positions of the mode switch, the LEVEL control allows the triggering point to be moved with respect to the signal. In AUTO the LEVEL control is inoperative.

NOTE: The full scale capability of the LEVEL control is equivalent to 12 cm of signal.

㉛ EXT socket: BNC socket allows an external trigger to be connected.

2.4 FIRST TIME OPERATION

This section provides a routine to enable you, particularly if unfamiliar with oscilloscopes, to obtain a trace on the screen derived from the internal calibration circuits.

Switch the POWER ON and set the front panel controls as follows:

Dual trace unit

(i) DISPLAY switch to CH1.

(ii) CH1 VOLTS/CM switch to CAL.

(iii) CH1 VARIABLE VOLTS/CM control fully counter-clockwise.

(iv) TRIGGER switch to CH1.

(v) CH1 POLARITY switch to NORMAL.

A sweep unit

(i) DISPLAY switch to B.

(ii) DELAY switch to OFF.

(iii) SWEEP switch to NORM.

Single sweep unit

This unit may be fitted instead of an A sweep unit.

(i) SWEEP switch to NORM.

B sweep unit

(i) TIME/CM switch to 1 msec/cm.

(ii) Horizontal MAG switch to x1.

(iii) Trigger switch to AUTO.

(iv) SOURCE switch to INT.

Now press the TRACE FINDER button and at the same time adjust the following controls until a picture is seen centred on the screen:

(i) INTENSITY control on the main frame.

(ii) POSITION control on the horizontal amplifier.

(iii) CH1 VERTICAL POSITION control on the dual trace unit.

Release the TRACE FINDER button and adjust the FOCUS, ASTIG and INTENSITY controls to produce the sharpest trace.

You have now obtained a picture on the screen derived from the internal calibration circuit. It is now recommended that you should observe how the trace is affected by operation of the following B sweep controls (return each control to its original position after use).

(i) TIME/CM switch.

(ii) VARIABLE TIME/CM control.

(iii) Preset LENGTH control (reset to trace length i.e. 10 cm).

(iv) x1 - x5 - x10 MAG switch on the horizontal amplifier.

NOTE: Because the x10 MAG position of the horizontal amplifier is frequency compensated to give the best results on the 0.05 μs/cm sweep, it gives overcompensated performance on the 0.1 μs/cm sweep. Therefore for best accuracy 10 ns/cm should be selected by x5 on 0.05 μs/cm and not by x10 on 0.1 μs/cm.

(v) Switch the SLOPE switch from + to - and note the change of triggering point on the screen.

(vi) Set the TRIGGER mode switch to AC and adjust the LEVEL control noting that the triggering point moves up and down the leading edge of the display.

NOTE: Operate the SLOPE and trigger LEVEL controls together with the NORMAL - INVERT POLARITY switch on CH1 on the dual trace unit and note how the trace triggering is affected. Operate the VERTICAL POSITION controls and GAIN switch and note how the display is affected.

(vii) Check that both sweep units have their TRIGGER modes switched to AUTO and the A sweep trigger SOURCE switch in the INT position.

(viii) Set the A sweep DISPLAY switch to A+B.

Press in and adjust the A only INTENSITY control if necessary for clear display.

Now adjust the corresponding A sweep controls as with B sweep and familiarize yourself with their functions.

With the A sweep DISPLAY switch in the ALT position, the oscillocope will display both sweeps alternately at velocities depending upon the relative settings of the A and B sweep controls. (These controls may be adjusted to note their effects on the picture.)

The two sweeps displayed may be separated vertically by adjustment of the TRACE SEPARATION control on the main frame.

The intensity of the A sweep may be adjusted independently of the B sweep by pressing in the INTENSITY control and adjusting it whilst pressed. In the normal position, the INTENSITY control adjusts both A and B sweeps equally. You may now display an external signal by connecting to the CH1 input socket. Set the input switch as required and the VOLTS/CM switch to a convenient position.

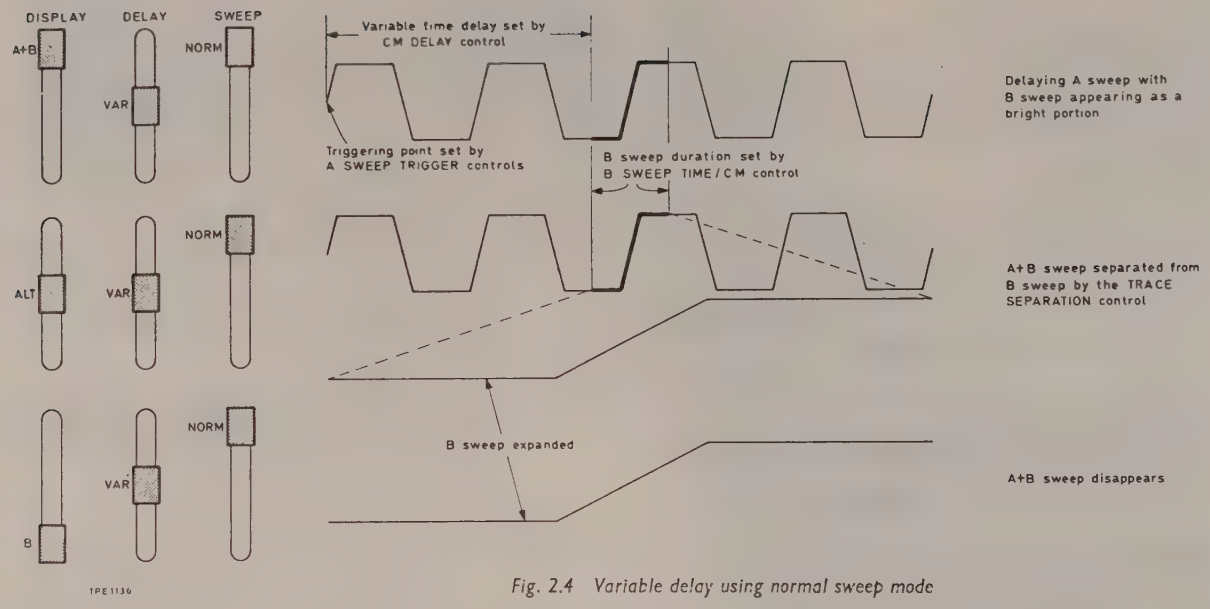


Fig. 2.4 Variable delay using normal sweep mode

2.5 USE OF DELAYING SWEEP

The following procedure is not intended as the normal step-by-step procedure for using the delaying time base, but should be regarded as a guide to those who have not used a delaying time base before. After following and understanding the principles of operation described below, you will probably develop your own 'short-cut' methods.

Variable delay—normal sweep mode

Set the DELAY switch to VAR and the SWEEP switch to NORM.

(1) Display a waveform as already described in Sect. 2.4.

(2) Set the DISPLAY switch to A+B and adjust the delaying A sweep trigger level and SLOPE controls to obtain triggering on the required part of the waveform.

(3) Set the A (only) INTENSITY control to about its mid position and the B sweep TIME/CM switch to a position (say 50 μsec/cm) which will give adequate duration of the delayed sweep. Decide which part of the displayed waveform you wish to examine and turn the CM DELAY control until the brightened portion, or delayed B sweep, covers that part of the waveform.

(4) Set the DISPLAY switch to ALT. Two traces will now appear on the screen, if they are superimposed adjust TRACE SEPARATION so that each waveform can be clearly viewed. It will be observed that the second trace is the delayed B sweep expanded to the full width of the screen.

NOTE: Adjustment of the A & B or A INTENSITY control may be necessary in order to see both traces clearly.

(5) Adjustment of the CM DELAY control will vary the position of the delayed B sweep along the delaying A sweep and the expanded B sweep will vary accordingly.

(6) Set the DISPLAY switch to B and the A+B trace disappears. This allows the B sweep to be scrutinized and expanded vertically to fill the whole screen by means of the appropriate VOLTS/CM control.

Variable delay—dual sweep mode

Set the DELAY switch to VAR and the SWEEP switch to DUAL.

(1) Display a waveform as already described in Sect. 2.4.

(2) Set the DISPLAY switch to A+B and the A sweep trigger mode switch to AC. Adjust the delaying A sweep trigger LEVEL and SLOPE controls to obtain triggering on the required part of the waveform. Set the A (only) INTENSITY control to about its mid position. Two bright

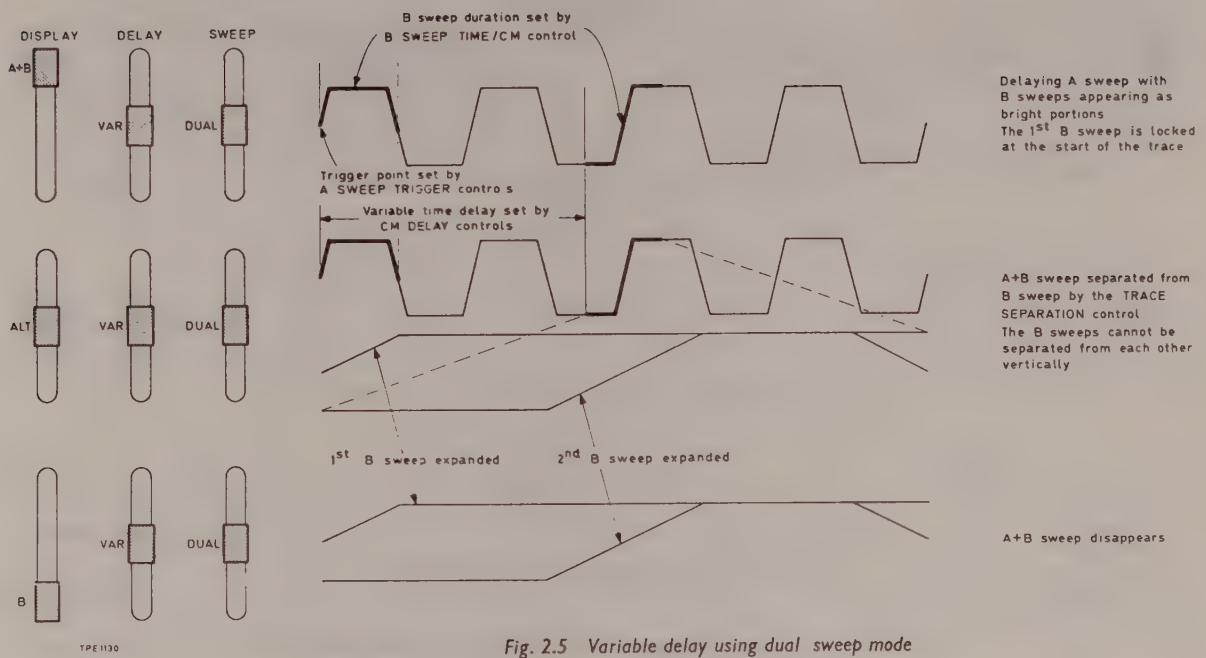


Fig. 2.5 Variable delay using dual sweep mode

portions will appear on the trace representing two B sweeps, see note (i). The first of these sweeps is locked to the start of the delaying A sweep and the triggering point is set by the A sweep trigger controls. The second B sweep will start at a point determined by the CM DELAY control.

NOTE (i): Depending on the B sweep TIME/CM switch setting, a waiting period (defined by the minimum time between the end of the first B sweep and the start of the second) is inevitable. Therefore, if the CM DELAY is set to a point between the start of the A sweep and the end of the waiting period, no second B sweep will occur.

(3) The duration of both delayed B sweeps is set by the B sweep TIME/CM control and the CM DELAY control will vary the position of the second B sweep only.

(4) Set the DISPLAY switch to ALT and adjust TRACE SEPARATION so that the A+B sweep is displayed separately from the two superimposed B sweeps.

NOTE (ii): Adjustment of the A+B or A INTENSITY control may be necessary in order to see both traces clearly.

(5) Set the DISPLAY switch to B and the A+B sweep disappears. This allows the B sweeps to be expanded vertically to fill the whole screen.

Triggered delay—normal sweep mode

Set the DELAY switch to TRIG and the SWEEP switch to NORM.

(1) Display a waveform as already described in Sect. 2.4. Set the DISPLAY switch to A+B. Set the A (only) INTENSITY to about its mid position. The delaying A sweep will appear with the delayed B sweep indicated as a bright portion. The trace is slightly dimmed to indicate that the gate is opened in this mode although careful adjustment of the INTENSITY controls will be needed to see this clearly. The triggering of the A+B sweep is set by the A sweep trigger controls.

(2) Decide which part of the trace you would like to observe, and rotate the CM DELAY control until the bright portion appears as close as possible to that part of the trace. As the CM DELAY control is rotated, the delayed B sweep will move in 'jumps' to the nearest identical triggering point in the direction of travel.

(3) Now set the B sweep, with its trigger controls, until the desired part of the waveform is brightened.

(4) Set the DISPLAY switch to ALT. The A+B trace and the expanded B trace will appear together. They can be separated by the TRACE SEPARATION control.

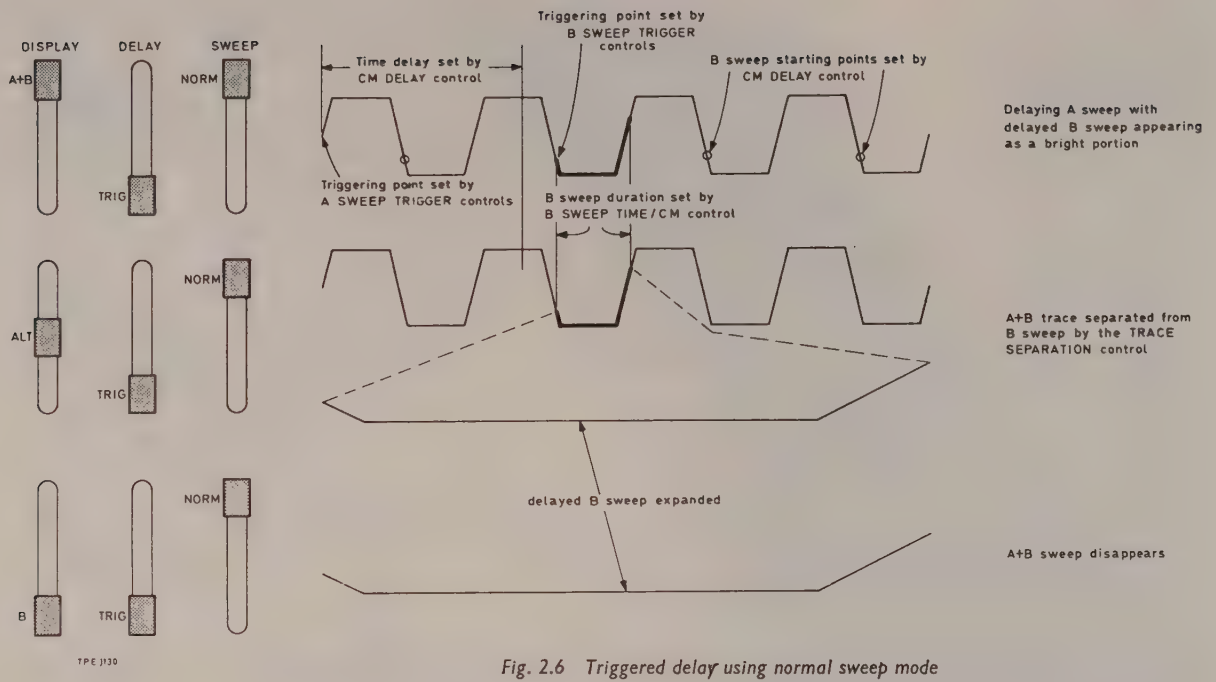

DISPLAY
DELAY
SWEEP
A+B
NORM
TRIG
ALT
B
TPE 1130
Triggering point set by B SWEEP TRIGGER controls
Time delay set by CM DELAY control
B sweep starting points set by CM DELAY control
Triggering point set by A SWEEP TRIGGER controls
B sweep duration set by B SWEEP TIME/CM control
delayed B sweep expanded
Delaying A sweep with delayed B sweep appearing as a bright portion
A+B trace separated from B sweep by the TRACE SEPARATION control
A+B sweep disappears

Fig. 2.6 Triggered delay using normal sweep mode

NOTE (i): Adjustment of the A+B or A INTENSITY control may be necessary to order to see both traces clearly.

(5) Set the DISPLAY switch to B and the A+B trace disappears, allowing the B trace to be expanded vertically to fill the whole screen.

Triggered delay—dual sweep mode

Set the DELAY switch to TRIG and the SWEEP switch to DUAL TRIG.

(1) Display a waveform as already described in Sect. 2.4. Set the DISPLAY switch to A+B and adjust the delaying A sweep trigger LEVEL and SLOPE controls to obtain triggering on the required part of the waveform. Set the A (only) INTENSITY control to about its mid position. Two bright portions will appear on the trace representing two B sweeps, see Note (ii). The first of these sweeps is locked to the start of the delaying A sweep and the triggering point is set by the A sweep trigger controls. The trace is slightly dimmed to indicate that the gate is opened in this mode although careful adjustment of the INTENSITY controls will be needed to see this clearly.

(2) Decide which part of the trace you would like to compare with the first bright portion, or first B sweep, and rotate the CM DELAY control until the second bright portion appears as close as possible to that part of the waveform. As the CM DELAY control is rotated, the second B sweep will move in 'jumps' to the nearest identical triggering point in the direction of travel.

(3) The B sweep TIME/CM control sets the duration of both delayed B sweeps. Set accordingly.

(4) Now set the DISPLAY switch to ALT. The A+B trace and the two expanded B traces will appear together. They can be separated by the TRACE SEPARATION control but the two B traces may not be separated from each other vertically.

NOTE (i): Adjustment of the A+B or A INTENSITY control may be necessary in order to see both traces clearly.

(5) Set the DISPLAY switch to B and the A+B trace disappears, allowing the B traces to be expanded vertically to fill the whole screen.

NOTE (ii): Depending on the B sweep TIME/CM switch setting a waiting period (defined by the minimum time between the end of the first B sweep and the start of the second) is inevitable. Therefore, if the desired triggering point is between the start of the first B sweep and the end of its waiting period, it cannot be used to trigger the B sweep.

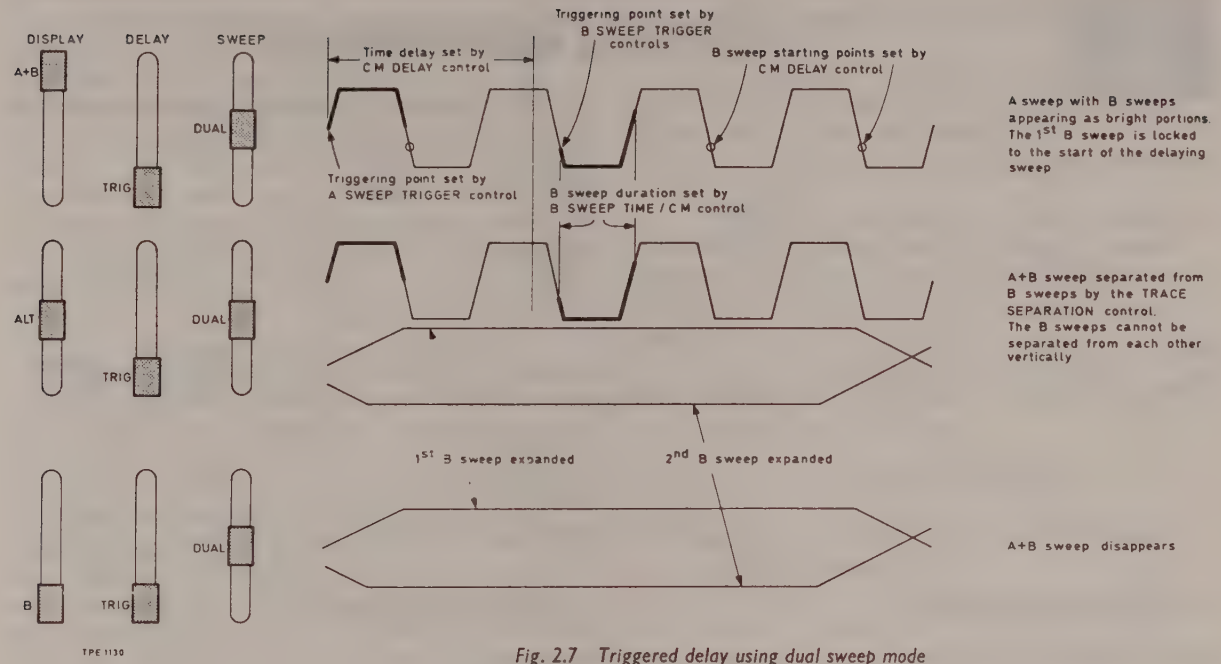

DISPLAY
DELAY
SWEEP
A+B
DUAL
TRIG
ALT
B
Triggering point set by B SWEEP TRIGGER controls
Time delay set by CM DELAY control
B sweep starting points set by CM DELAY control
Triggering point set by A SWEEP TRIGGER control
B sweep duration set by B SWEEP TIME / CM control
A sweep with B sweeps appearing as bright portions. The 1st B sweep is locked to the start of the delaying sweep
A+B sweep separated from B sweeps by the TRACE SEPARATION control. The B sweeps cannot be separated from each other vertically
1st B sweep expanded
2nd B sweep expanded
A+B sweep disappears
TPE 1130

Fig. 2.7 Triggered delay using dual sweep mode

2.6 SINGLE SWEEP OPERATION

The SWEEP switch, when in the SINGLE position, permits single sweeps for photographic purposes when the DISPLAY is set to either A+B or B and in any position of the DELAY switch.

Triggering is provided by the appropriate trigger controls in either an a.c. or d.c. mode. If AUTO is selected, a near instantaneous single sweep will occur when the RESET button is pressed.

With the appropriate trigger LEVEL control set to a predetermined triggering amplitude and the SWEEP switch set to SINGLE, normal triggering will cease.

(a) If the input waveform is not present or its amplitude is too small to provide triggering at the selected LEVEL settings:

Press the RESET button and the light will glow. Upon receipt of an input waveform of sufficient amplitude to operate the trigger circuit, one sweep of the selected time base will occur and the light will be extinguished.

(b) If the input waveform is present and its amplitude is sufficient to provide triggering at the selected LEVEL setting:

Press the RESET button and a single sweep of the time base will occur - triggered by the selected triggering point on the waveform.

With very slow sweep speeds it will be observed that the light remains on after the button is released, to be extinguished upon completion of the sweep.

This means that at most time base settings the action of pressing the RESET button appears to initiate the sweep and turn the light on; in reality, the sweep is triggered by the waveform and is completed by the time the button is fully depressed.

Chapter 3

Technical description

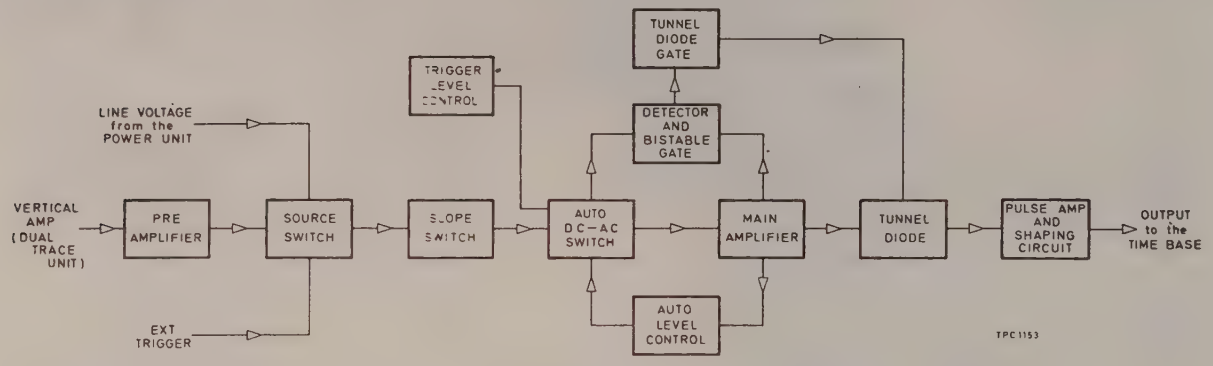


Fig. 3.1 Systematic block diagram of the trigger circuit

3.1 TRIGGER CIRCUITS

Basic system—board A12

Triggering signals can be selected from three sources; internal from the vertical amplifier; from the supply frequency, and external from the front panel input socket, see Fig. 3.1. All incoming signals are routed through the SOURCE switch, the AUTO-DC-AC switch, and the SLOPE switch which, depending on its position, applies the signal to either side of the main amplifier.

Internal signals are pre-amplified by VT1 and VT2 and fed via the switching to the main amplifier VT3 to VT8. The output of VT7 is fed to a tunnel diode which, in a.c. and d.c. modes, forms a bistable circuit. The output from the bistable is shaped into a pulse by VT14 and fed to the time base. In the auto mode, the tunnel diode becomes a free running oscillator by changing its load line and bias current. This ensures, in the absence of signal, a bright line display on the c.r.t. When the incoming signals are above 5 MHz, the tunnel diode remains in this state and is synchronized to the incoming signal by adjustment of RV4b (A7) which is ganged to the LEVEL control. RV4b varies the count down rate. When the incoming signals are below 5 MHz, the signals are detected at the collector of VT8 and converted to d.c. which changes the state of the tunnel diode into a bistable.

The trigger LEVEL control is removed from circuit in the auto mode and a feedback loop, over the main amplifier, ensures that the input waveform is approximately centred on the display irrespective of waveshape.

Circuit analysis—board A12

See Fig. 7.10

Incoming signals from the vertical amplifier are current driven into VT1 and VT2 which form a shunt feedback stage. This gives a low impedance drive for the input emitter followers VT3 and VT4. The input pre-amplifier stage is balanced by RV1.

External triggering signals are fed to a source follower, VT17, and then to the emitter follower stage VT18 which drives VT3 and VT4. RV3 adjusts the output of VT18 to be nominally 0 V and also compensates for variations in the field effect transistor.

All incoming signals are fed into the input emitter followers VT3 and VT4. These signals are balanced on internal triggering and single sided on external and line triggering. The output signals from VT3 and VT4 are fed into two series feedback stages VT5, VT6, VT7 and VT8. The output of VT7 is fed into the tunnel diode, MR3, via a filter circuit, MR2 and C10.

In the a.c. and d.c. modes, VT10 is non-conducting whilst VT15 is conducting. This gives a load line consisting of L2 and R44. The tunnel diode circuit then operates as a bistable. Signals appearing across MR3 are fed to the base of VT14 which, due to the time constant in its emitter circuit, turns the square wave output of the tunnel diode into a pulse of approximately 3 V amplitude and 100 nsec width. T1 in the collector of VT14 gives the correct output polarity to trigger the time base.

In the auto position of the mode switch, VT15 and VT11 are turned off and VT10 turned on. Therefore the load line becomes L1, R40. An additional bias current passes through R50 and R54 via a 1 kΩ control, RV4b (A7) ganged to the LEVEL control. The tunnel diode is then in an astable state and free runs at approximately 1 MHz. This frequency is adjustable by RV4b allowing the oscillator to be synchronized with incoming high frequency signals.

The output from VT8 is coupled into the phase splitter, VT9, which gives a low impedance output at both emitter and collector. The signal appearing across R41 is rectified by MR6 and MR7 and gives a d.c. control signal to operate VT13. The frequency response of this stage is limited to approximately 5 MHz by R41 and C11. Thus with input signals above 5 MHz, there is no d.c. control signal available across C16, and the tunnel diode remains in an astable state. When the input signals are below 5 MHz, a d.c. control signal is available across C16 which causes the emitter coupled bistable, VT13 and VT16, to change state; i.e. VT13 turned off and VT16 turned on.

VT11 and VT15 conduct and the tunnel diode then acts as a bistable. The action of VT11 conducting turns VT10 off and the load line becomes L2 and R44. The d.c. current through R54 bypasses MR3 by the clamping action of VT11.

During auto modes the LEVEL control is switched out of circuit and the preset bias control RV2 ensures triggering on the minimum input signal.

When the tunnel diode is in an astable state, MR2 is turned off and VT7 is coupled to the tunnel diode via C10 which forms a high-pass filter. This filter ensures that unwanted low frequency signals are effectively removed from the tunnel diode. When MR3 is in the bistable state, MR2 conducts, ensuring a d.c. connection between VT7 and the tunnel diode.

The positive and negative excursions of VT9 emitter are rectified and fed back to the input of the main amplifier via VT12. This ensures centring of the triggering point irrespective of the waveform. The feedback loop is rendered inoperative on a.c. and d.c. In the a.c. and d.c. mode, -15 V is applied to R59 which turns off VT13, ensuring that the tunnel diode remains in the bistable state irrespective of any signal appearing across R41.

3.2 SWEEP FUNCTION SYNOPSES

The following descriptions and block diagrams show how each sweep function is evolved in the instrument. A detailed circuit analysis of each board in the sweep unit follows the function synopses.

In the sweep circuits the principal waveforms are indicated, in this chapter and on the circuit diagrams, by codes such as 1G, 2AB. The following table gives the meanings of all the codes used.

2A: Square wave equal in period to the A sweep unblanking waveform.

3A: The A sweep saw-tooth waveform.

2B: Square wave equal in period to the B sweep unblanking waveform.

3B: The B sweep saw-tooth waveform.

2AB: Square wave which is in its positive state whenever 2A or 2B is positive (i.e. 2A OR 2B).

1G: Triggered delay gating waveform. A square wave whose positive state equals the period from the start of the variable delayed sweep to the completion of either the delayed sweep run-up or the delaying sweep run-up, whichever occurs first.

1XZ: A square wave generated by a bistable which is switched by 2A, 2B or 2AB, depending on the setting of the sweep function switches; i.e. the DISPLAY, DELAY and SWEEP lever switches.

$\overline{1XZ}$: A waveform opposite in polarity to 1XZ.

A sweep normal

DELAY switch to OFF
SWEEP switch to NORM
DISPLAY switch to A+B

See Fig. 3.2

NOTE: With this combination of switch positions the DISPLAY switch provides an A sweep only. The +B (in red) applies to delayed modes only.

The trigger pulses are fed from board A12 into the A14 sweep board via pin 23, to the trigger gate transistor, VT2. The positive-going pulse

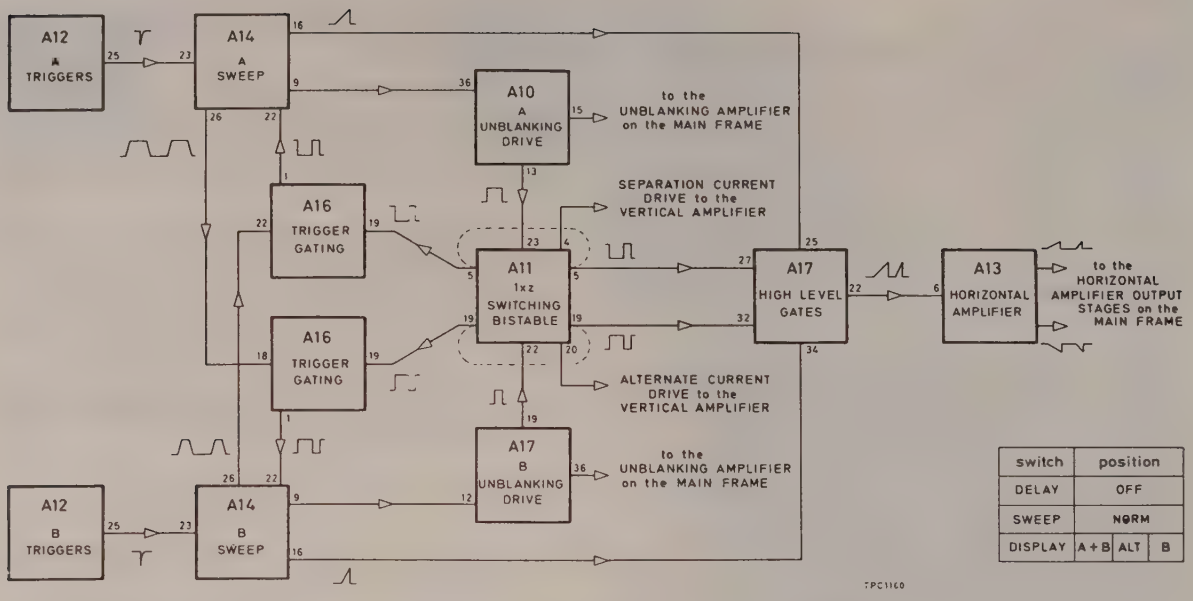


Fig. 3.2 Functional block diagram—normal sweeps with no delay

developed at the collector of VT2 is coupled into a 1:1 ferrite transformer and fed, as a positive-going spike, via MR4 to the transistor VT3. VT3 and VT5 form the sweep start bistable. VT3 is turned on and a step waveform is produced at its collector which open circuits the disconnect diode MR12 to the grid of V1. This renders the waiting point amplifier, MR9, VT9 and VT10 inoperative. The nuvistor V1 is used in a cathode follower mode and drives the base of the Miller run-up transistor VT11. A linear Miller run-up waveform is developed at the collector of VT11 and is fed out via pin 16. The Miller run-up is returned to the base of VT5, via MR7, resetting the sweep start bistable thus terminating the run-up period.

The sweep is fed out from A14 to the high level sweep gates on board A17. A proportion of the sweep signal is fed via VT12 to the front panel SWEEP OUT socket. The A high level sweep gate consists of MR1, MR3 and VT1. The B gate, which is held closed in this function, consists of MR2, MR4 and VT2. The high level sweep gates are operated by a sweep switching bistable (1XZ) which is situated on board A11 and comprises basically VT10 and VT11. In this mode, i.e. DISPLAY - A+B, the 1XZ bistable is biased by a d.c. command from the DISPLAY switch to open the A high level sweep gate and close the B high level gate. Thus the A sweep is passed through the gate to the horizontal amplifier on board A13. All the horizontal amplifier front panel controls operated on board A13.

A balanced current drive sweep output is taken from A13 board to the horizontal amplifier output stages which are adjacent to the c.r.t. horizontal deflection plates on the main frame.

The outputs from the 1XZ sweep switching bistable are also taken via the trigger gating circuits on both A16 boards in the A and B sweep units, to the trigger gate transistors VT2 on both A14 boards. When DISPLAY - A+B is selected, the outputs from the bistable open the A sweep trigger gate and close the B sweep trigger gate.

A current drive is taken from VT5, part of the sweep start bistable, on the A sweep board (A14) to produce the A unblanking drive. This is controlled through the A & B or A INTENSITY control on the front panel via VT4 on A10 and via pin 15 to the unblanking amplifier, situated at the base of the c.r.t. The current drive from VT5 is also used to produce a gate signal which is fed to the front panel GATE OUT socket from VT7 on A10.

A voltage waveform, known as 2A which has the same duration as the Miller run-up waveform, is developed by VT5 and VT6 in the unblanking drive generator on A10. A current drive signal for the vertical amplifier alternate mode, is produced by the alternate bistable VT15 and VT16, on board A11 of the A sweep unit, and fed via pin 20, to the dual trace unit. In the display A+B mode, the bistable is driven by the A2 signal.

B sweep normal

DELAY switch to OFF
SWEEP switch to NORM
DISPLAY switch to B

See Fig. 3.2

In this function the B sweep is displayed instead of the A sweep. Since some of the stages in the B unit are identical to the corresponding stages in the A unit, any aspect of operation not covered in this description should be referred to the previous synopsis.

The B sweep is fed from the A14 board into tag 34 of the high level sweep gates, board A17. The high level sweep gate action is controlled by the sweep switching bistable (1XZ) and in this function, the B high level gate is held open and the A gate held closed.

The 1XZ bistable is biased by a d.c. command from the DISPLAY switch. The B sweep is therefore passed through the high level sweep gates to the horizontal amplifier on board A13. The signal leaves A13 as a balanced current drive to the horizontal amplifier output stages.

When DISPLAY - B is selected, the outputs from the 1XZ bistable open the B sweep trigger gate and close the A sweep trigger gate therefore reversing the gate operation described previously in display - A+B.

The B unblanking drive is produced by a current drive signal from the B sweep board A14. The B unblanking drive circuits on board A17 are controlled, via tag 14, by the A & B INTENSITY control on the front panel. The unblanking drive output is fed from VT3, via pin 36 board A17, to the unblanking amplifier at the base of the c.r.t. The current drive from A17 is also used to develop a gate signal which is fed out via VT6, pin 3, to the GATE OUT socket on the front panel (B unit).

A voltage waveform, known as 2B which has the same duration as the Miller run-up waveform, is developed by VT4 and VT5 in the unblanking drive generator on A17. A current drive signal for the vertical amplifier alternate mode, is produced by the alternate bistable VT15 and VT16, on board A11 of the A sweep unit, and fed via pin 20 to the dual trace unit. In the display - B mode, the alternate bistable is driven by the 2B signal.

Alternate sweeps

DELAY switch to OFF
SWEEP switch to NORM
DISPLAY switch to ALT

See Fig. 3.2

In this mode the A and B sweeps run alternately, each sweep being developed as described in the previous two synopses.

In the alt mode, the 1XZ bistable is not biased by d.c. commands from the DISPLAY switch, but is operated alternately by the negative going edge of the 2A or 2B waveform.

Since the duration period of the 2A and 2B waveforms are the same as the Miller run-up signals, the 1XZ bistable switches over at the end of each sweep. This allows the sweeps to pass alternately through the high level sweep gates to the horizontal amplifier.

The 1XZ bistable also supplies signals to operate the trigger gating to the A sweep board, A14 in the A unit, and to the B sweep board, A14 in the B unit, so that when the A sweep is running, triggers are locked out from the B sweep and vice versa. See Fig. 3.3.

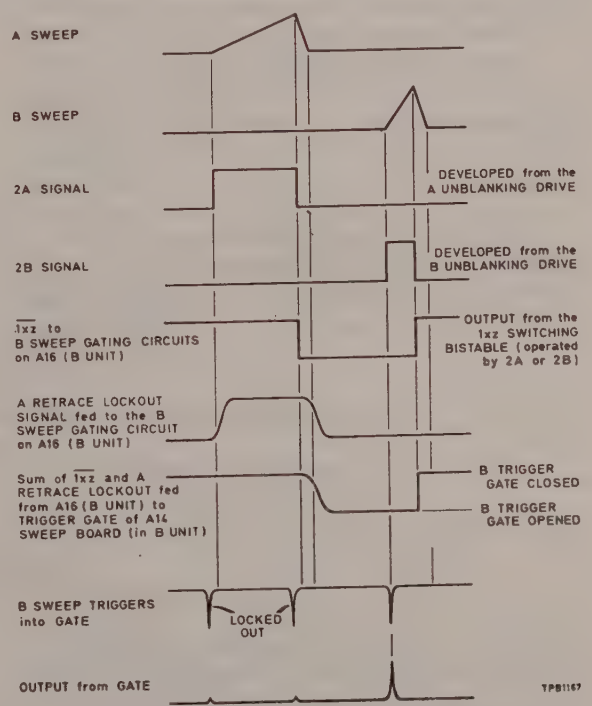

A SWEEP
B SWEEP
2A SIGNAL
DEVELOPED from the A UNBLANKING DRIVE
2B SIGNAL
DEVELOPED from the B UNBLANKING DRIVE
1xz to B SWEEP GATING CIRCUITS on A16 (B UNIT)
OUTPUT from the 1xz SWITCHING BISTABLE (operated by 2A or 2B)
A RETRACE LOCKOUT SIGNAL fed to the B SWEEP GATING CIRCUIT on A16 (B UNIT)
Sum of 1xz and A RETRACE LOCKOUT fed from A16 (B UNIT) to TRIGGER GATE of A14 SWEEP BOARD (in B UNIT)
B TRIGGER GATE CLOSED
B TRIGGER GATE OPENED
B SWEEP TRIGGERS into GATE
LOCKED OUT
OUTPUT from GATE
TPB1167

Fig. 3.3 Waveforms showing the evolution of the B sweep trigger gating waveform. The A sweep trigger gating is developed from the addition of the 1XZ and the B retrace signal in the gating circuits of the A unit and fed to the A trigger gate

In the DISPLAY - ALT position, the A and B sweeps require to be vertically displaced for clear presentation. It is therefore necessary to provide a switched offset signal in the vertical direction, to separate the two sweeps.

This signal is controlled by the TRACE SEPARATION control on the front panel. The separation signal is derived from the 1XZ bistable and is fed through VT14 out of board A11, via pin 4, to the vertical amplifier (dual trace unit).

An output from the 1XZ bistable drives the alternate bistable on A11 when in the display - alternate mode. This alternate bistable provides a current drive signal, via VT17, through pin 20 to the vertical amplifier for alternate dual channel operation.

A retrace lockout signal is developed on each sweep board to prevent retriggering before the Miller stage has reached a quiescent stage. In the alternate mode the retrace lockout signals from VT13, in each A14 sweep board, are cross coupled between the two trigger gates. This ensures that the A sweep cannot be triggered until the B sweep has reached a quiescent state and vice versa, see Fig. 3.3.

Delaying sweep: variable

DELAY switch to VAR
SWEEP switch to NORM
DISPLAY switch to A+B

See Fig. 3.4

In this mode, the A sweep is used in conjunction with a delay pick-off circuit to provide a delayed B sweep. The A sweep is triggered and operates as described in the previous display - A+B synopsis. The A sweep run-up waveform is fed from the A14 sweep board, via pin 16, into pin 25 of the high level sweep gates on board A17. This signal is also fed into the delay pick-off circuits on board A11, via pin 16. The 1XZ bistable and the high level sweep gates operate as described in the previous display - A+B synopsis.

The A sweep is fed into the delay pick-off circuits to VT1 which is an emitter follower stage that feeds the signal, via MR1 and MR2, to a delay pick-off Schmitt circuit, VT2 and VT3. The voltage point at which the Schmitt circuit switches, along the sweep run-up waveform, is determined by the setting of the CM DELAY control on the front panel. This action determines the amount of delay between the start of the A sweep and the start of the B sweep.

A differentiated pulse derived from the delay pick-off waveform is fed out of A11 through VT7, via pin 34, to the B unit. This pulse is fed into pin 20 of the B sweep board A14 and triggers the B sweep run-up.

The B sweep trigger pulse is not fed through VT2 on A14, as in the previous functions, but through a diode gate, MR3. This gate is allowed to open only in the DELAY - VAR position by absence of a bias signal from the DELAY switch. VT2 is reversed biased by a signal fed to the trigger gating circuits on A16 from the DELAY

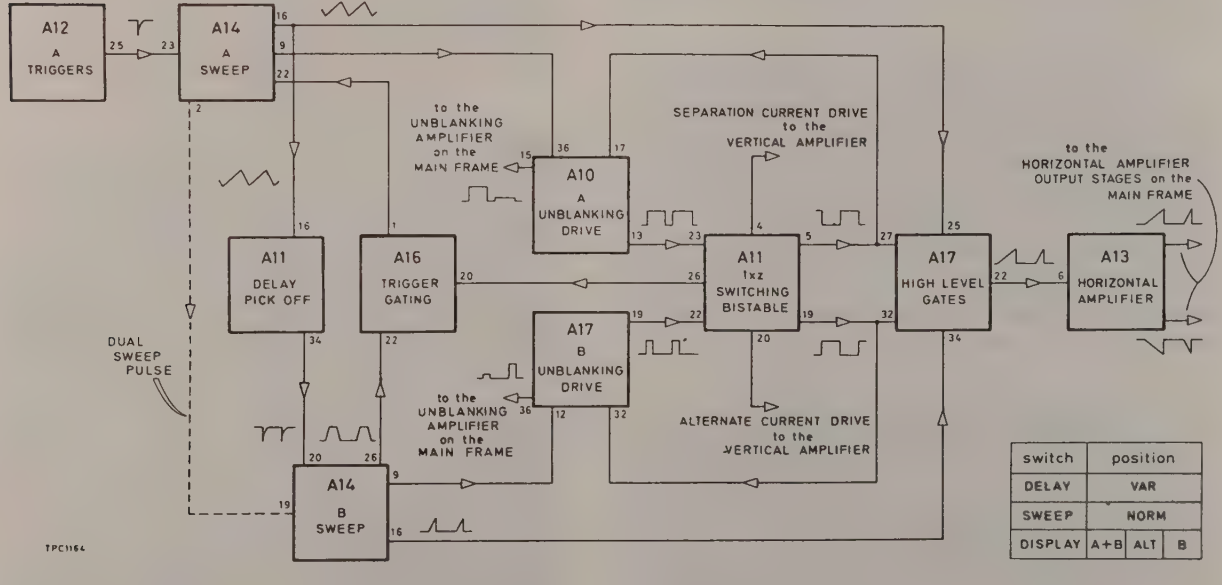


Fig. 3.4 Functional block diagram—normal sweeps with variable delay

switch. The B sweep runs, but the high level sweep gates are biased so that only the A sweep passes to the horizontal amplifier.

The B sweep circuit drives the B unblanking circuit on A17. The unblanking drive signal from the B unit is fed out from pin 36 of A17 to the unblanking amplifier so that the B unblanking drive signal is added to the A unblanking drive signal at the emitter input of the unblanking amplifier on the main frame. The A unblanking drive can be controlled separately by the A only INTENSITY control on the front panel. Therefore the intensity of B bright-up can be adjusted relative to the A trace intensity. The complete B unblanking drive signal is not required as well as the A unblanking drive fed to the unblanking amplifier. for this would result in a highly intense delayed B sweep portion on the A trace. The B unblanking is, therefore, reduced. This is achieved by feeding a signal ($\overline{1XZ}$) from the 1XZ bistable to pin 82 of board A17. This signal diminishes the amount of B unblanking drive fed out from the B unblanking drive circuit.

The A sweep is prevented from being retriggered until the A+B sweep sequence is completed. A gating signal from the trigger gating circuits on board A16 (A unit). is fed to the trigger gate transistor, VT2 on A14 (A unit). This signal is the sum of the duration of the 2A, 2B and B sweep retrace lock-out waveforms. The 2A and 2B durations are added together in a diode OR gate, MR4 and MR5 on A11. The output 2AB, is fed from the emitter follower, VT8, through pin 26 of A11 to the A trigger gating circuits, via pin 20 of A16 in the A unit. The B sweep retrace lock-out signal is fed from pin 26 of the B sweep generator, A14 in the B unit to pin 22 of the A trigger gating circuits on A16 The durations of the 2AB and B retrace lock-out signals are added together in a diode OR gate, MR6 and MR8, on board A16. The combined output signal is then fed to the A sweep trigger gate from the emitter follower, VT1, on A16. See Fig. 3.5.

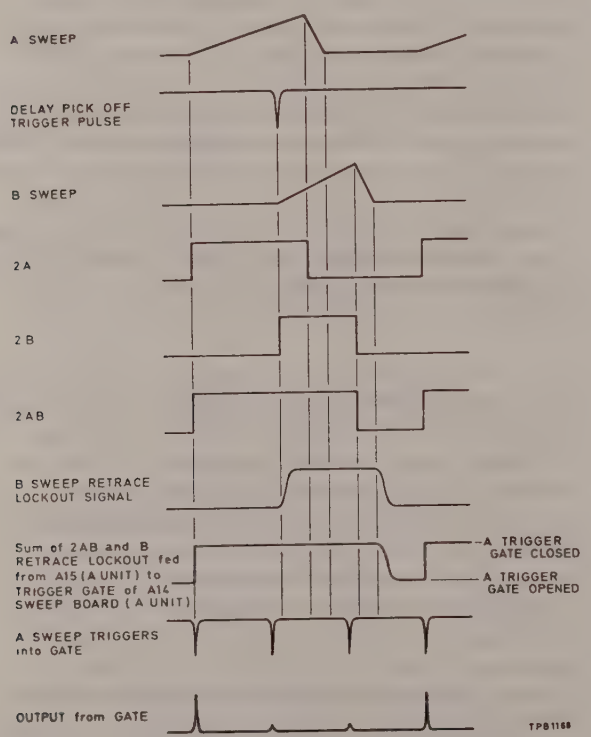

A SWEEP
DELAY PICK OFF TRIGGER PULSE
B SWEEP
2A
2B
2AB
B SWEEP RETRACE LOCKOUT SIGNAL
Sum of 2AB and B RETRACE LOCKOUT fed from A15 (A UNIT) to TRIGGER GATE of A14 SWEEP BOARD (A UNIT)
A TRIGGER GATE CLOSED
A TRIGGER GATE OPENED
A SWEEP TRIGGERS into GATE
OUTPUT from GATE
TPB1168

Fig. 3.5 Waveforms showing the evolution of the A sweep trigger gating waveform. NOTE: B sweep trigger gate held closed by bias signal from the DELAY switch

Delayed sweep: variable

DELAY switch to VAR
SWEEP switch to NORM
DISPLAY switch to B

See Fig. 3.4

The essential differences between this and the previous mode are as follows:

The A sweep is suppressed in the high level sweep gate circuit by the 1XZ bistable, whilst the B sweep is displayed. The A unblanking drive is blocked by the 1XZ waveform which is fed to the A unblanking generator through pin 17 of board A10. The B unblanking generator is allowed to produce a full unblanking drive by the change in state of the 1XZ bistable.

As in previous functions, the state of the 1XZ bistable is controlled by a command from the DISPLAY switch. Therefore the state of the 1XZ bistable is this mode is opposite to that in the previous mode.

Variable delay sweeps: alternate

DELAY switch to VAR
SWEEP switch to NORM
DISPLAY switch to ALT

See Fig. 3.4

In this mode the A sweep and B delayed sweep run alternately, each sweep being developed as described in the previous two synopses, i.e. display - A+B and B delayed. The 1XZ bistable switches the high level gates thus selecting which sweep is displayed and also controls the unblanking drive of both the A and the B sweeps.

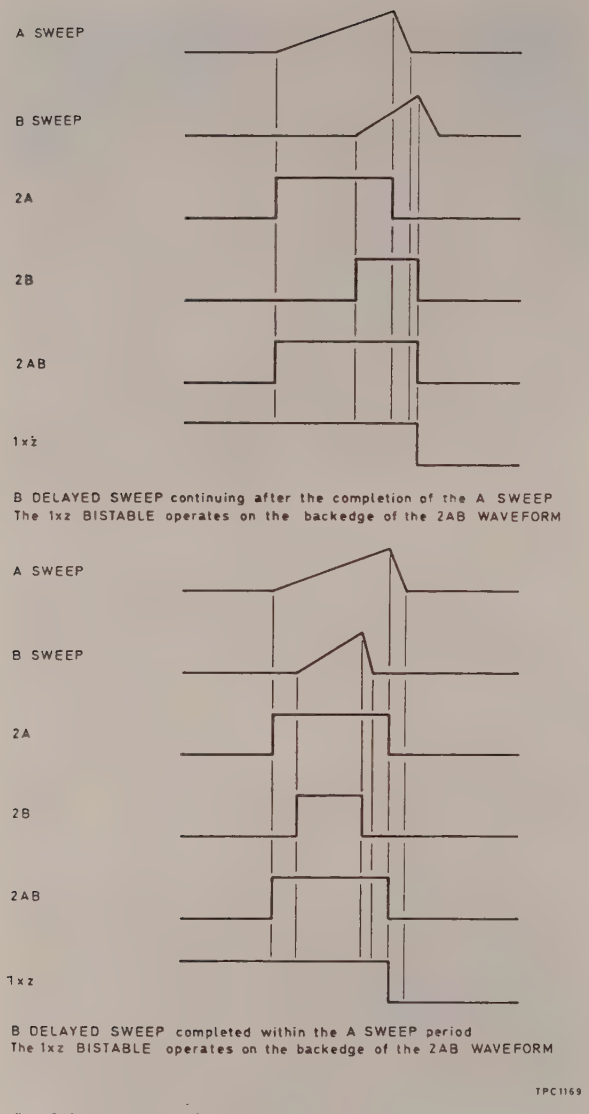


Fig. 3.6 Switching of the 1XZ bistable on alternate delaying modes

The 1XZ bistable is triggered by the back edge of the combined 2A and 2B waveforms, i.e. 2AB, which causes the bistable to switch at the last negative going edge of either the 2A or the 2B signal.

See Fig. 3.6 (switching of 1XZ in delaying mode).

An alternate current drive signal is provided from board A11 to the vertical amplifier, as described in the first function synopsis, to give alt - ch1 and ch2 operation of the dual trace unit. Also a current drive output to the dual trace unit is produced which gives a separation signal to vertically part the A+B trace from the B delayed trace. This signal is controlled by the TRACE SEPARATION control on the front panel.

Triggered delay sweeps

DELAY switch to TRIG
SWEEP switch to NORM
DISPLAY switch to A+B - ALT - B.

See Fig. 3.7

The three display functions in the delay - trig mode are very similar to the previous delay - var mode. The exception being that the pulse from the delay pick-off circuits on board A11, pin 34, is fed into board A10, via pin 1, instead of directly triggering the B delayed sweep. The pulse operates the triggered delay bistable VT8 and VT9 on A10, which produces an output known as 1G. The square wave signal, 1G, is fed from A10, via pin 6, to the trigger gating circuits on A16, via pin 20, in the B unit.

The trigger gating circuits are not held permanently closed by the DELAY switch, as in the VAR mode, but are operated by the 1G signal. The output from VT1 of the trigger gating circuits on A16 is fed as previously described to operate the trigger gate transistor, VT2, on board A14 of the B unit.

The normal state of the triggered delay bistable is such that the trigger gate, in the B sweep unit, is closed. The B sweep is therefore prevented from being triggered. Directly the triggered delay bistable receives the variable delay pick-off pulse, it changes state and opens the trigger gate on A14 via the trigger gating circuits on A16. This allows the first trigger pulse, from A12 trigger board, to arrive after the gate opens to start the B sweep run-up. If no triggers arrive from the B unit trigger board, the B sweep will not run and therefore no triggered B delayed sweep will occur.

The triggered delay bistable is reset to close the trigger gate into the B sweep by the negative-going edge of either the 2A or the 2B waveform, whichever is the first to arrive after the bistable is opened by the variable delay pick-off pulse. A description of how the 2A and 2B waveforms are derived, is covered in the preceding synopses. If no delayed B sweep is triggered, the 1G bistable is reset by the negative-going edge of the 2A waveform.

In order that the gate opening period can be seen on the c.r.t., a small proportion of the triggered delay bistable output, from pin 6 on A10, is fed into the A unblanking drive circuit, on A10, giving a very slight decrease in intensity of the A sweep display. This is only a very subtle change

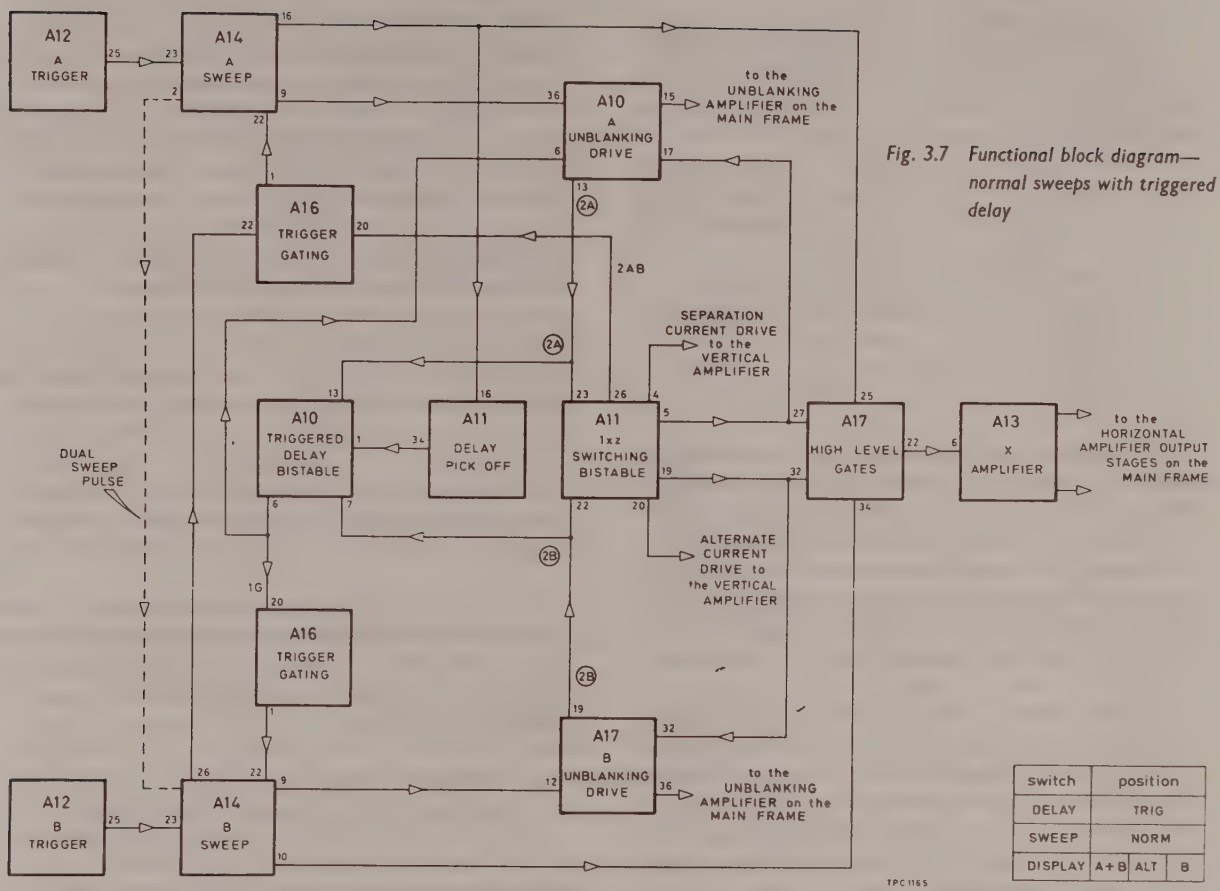


Fig. 3.7 Functional block diagram—normal sweeps with triggered delay

in brightness and careful adjustment of the INTENSITY control is required in order that this dimming effect may be seen.

In all other respects the block diagram and functioning of the delay - trig mode in the DISPLAY - A+B, ALT and B delayed switch positions are identical to the operation as described for delay - var mode.

3.3 DUAL SWEEP FUNCTION

DELAY - VAR or TRIG
SWEEP - DUAL
DISPLAY - A+B - ALT - B

See Fig. No's 3.4 or 3.7

Dual B sweep operation may be obtained in either the DELAY - VAR or TRIG switch positions. The circuit description is identical to that given for delay - var or delay - trig, depending on the position of the switch, except for the following details:

A pulse which occurs at the start of the A sweep is fed from the A sweep board via pin 2, to the B sweep board, via pin 19. A bias signal, fed from the SWEEP switch, gates this pulse out in the other two SWEEP switch positions. The action of the pulse is to trigger the B sweep almost instantaneously at the start of the A sweep, producing a brightened portion on the A+B sweep at the start of the scan. A second B sweep is initiated by the delay pick-off pulse (var) or by the B sweep trigger pulses after the delay pick-off has opened the gate (trig), as previously described.

In the DISPLAY - B switch position, the two B sweeps will be displayed superimposed, allowing detailed comparison of the two chosen points on the A+B sweep.

3.4 SINGLE SWEEP FUNCTION

DELAY switch to VAR or TRIG
SWEEP switch to SINGLE
DISPLAY switch to A+B or B

See Fig. 3.8

Single sweep operation can be obtained on all function positions with the exception of DISPLAY - ALT where the single sweep is locked out.

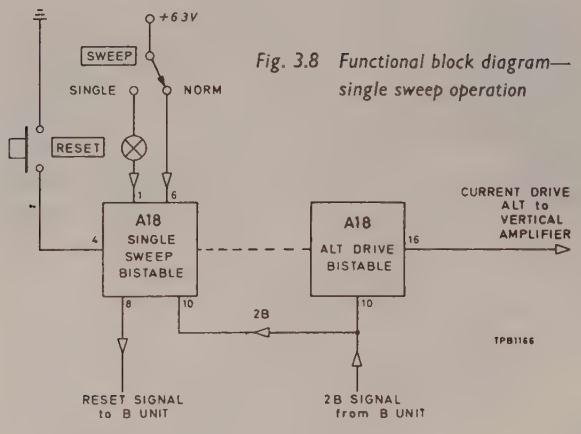


Fig. 3.8 Functional block diagram—single sweep operation

Single triggered sweeps are obtained as follows: The trigger gates, VT2, at the inputs to the A and B sweep boards, are opened via the gating circuits on boards A16 and closed at the end of the selected sweep run-up. The gating signal, to open VT2, is derived from the single sweep bistable on board A10, which is controlled by the RESET button through pin 21.

The output of the single sweep bistable is taken from pin 31 of A10 to pin 21 of the trigger gating circuits on boards A16. Both of the sweep trigger gating circuits receive the single sweep waveform from the bistable, but the gating circuit of the sweep not selected is biased off by a signal from the 1XZ bistable.

Having opened the trigger gate transistor, VT2, on the sweep board selected by the DISPLAY switch, the first trigger pulse to occur from the appropriate trigger board, A12, will start the sweep. At the end of the run-up the single sweep bistable is turned to its off state by a trigger signal fed in via pin 34 of board A10. This trigger signal is derived from the 2AB waveform, described in delay - var, display - A+B. This ensures that in delaying sweep modes the single sweep bistable is not turned to its off state until the whole sequence of the A sweep and delayed B sweep is completed.

The light associated with the RESET button on the front panel is illuminated by the single sweep bistable and remains on until the sweep or delaying sweep sequence has been completed. The light is driven from VT3 on A10 via pin 19.

The operation of the other circuits involved is as described for the sweep function selected.

Single sweep function synopsis

The single sweep unit is used in conjunction with the B sweep unit, replacing the A sweep unit, to provide a single sweep facility as opposed to dual or delay functions. It contains one printed board, A18, which provides a single sweep operation. Single sweeps are produced as follows: The SWEEP switch is set to SINGLE. The RESET button on the front of the unit is pressed and, via pin 4 of A18, turns off VT2 of the sweep start bistable. By the bistable action, VT3 is turned on and the output from its collector is coupled through pin 8, test point 1, to the trigger gating circuits (A16) in the B unit. This signal, via the trigger gating circuits, opens the trigger gate to the B sweep board A14. The first trigger pulse from the B trigger board, A12, passes through the gate and starts the Miller run-up. At the end of the run-up, a signal originating from the unblanking generator on A17, is fed into pin 10, test point 2, of A18 turning off VT3 and so closing the trigger gate to the B sweep. This prevents any further B sweeps until the single sweep bistable is reset.

The RESET light on the front panel is illuminated by VT1 which is driven from the collector of VT2. The light is turned on when the single sweep bistable is reset and is extinguished at the end of the sweep run-up.

When the SWEEP switch is set to NORMAL the single sweep bistable is out of circuit.

The single sweep unit also contains an alternate drive bistable which provides a current signal to the vertical amplifier for alternate dual trace unit use. The bistable is switched at the end of each B sweep run-up by a signal fed to pin 10, test point 2, of the A18 board.

3.5 SWEEP CIRCUIT ANALYSES

Board A10

This board contains the single sweep bistable, the A unblanking generator and the triggered delay bistable circuit.

The single sweep bistable consists basically of VT1 and VT2. In the NORM position of the SWEEP switch, VT1 is biased on and the RESET light is disconnected from its supply voltage by the SWEEP switch. In the SINGLE position of the SWEEP switch the bistable is operated by pressing the RESET button, which turns off VT2 and the bistable action turns on VT1. VT3 is turned on when VT2 is cut off and since the SWEEP switch is in the SINGLE position, the RESET light is illuminated. The output from the collector of VT1, through pin 31, test point 25, is turned to its most negative state opening the trigger gate to

the B unit. When the B sweep is triggered and runs, a negative-going pulse coincident with the end of the B sweep run-up, is fed to the base of VT1 via pin 34 and C1 in series with MR1. This pulse turns off VT1. VT2 is turned on by the bistable action, extinguishing the RESET light via VT3 and closing the trigger gate to the B unit.

NOTE: The above description applies only when the DISPLAY switch is in the B position.

The circuit functions similarly when the DISPLAY switch is set to A+B, i.e. the A sweep trigger gates are controlled instead of the B sweep trigger gates.

The A unblanking generator consists basically of diodes MR3, MR4, MR5 and transistors VT4, VT5, VT6 and VT7.

The unblanking generator drive transistor VT4 provides a current drive to the unblanking amplifier through MR4 to pin 15, test point 26. The current drive is controlled through a connection from the base of VT4 to the A and B INTENSITY control via pin 14; also by the A INTENSITY control via pin 16 to the base of VT4. VT4 also forms the collector load for one half of the sweep start bistable on board A14, via R18 and pin 36.

When the sweep run up is being produced no current is drawn from pin 36 into the collector circuit of the sweep start bistable, so that any collector current flowing in VT4 is passed through MR4 to the unblanking amplifier as an intensity drive signal. When the run-up has been completed collector current for the sweep start bistable is drawn from pin 36, thus removing the unblanking drive from MR4. MR5 clamps the maximum negative potential of the collector of VT4 to approximately -0.7 V. VT4 is controlled in the alternate delayed sweep modes by a signal (1XZ) from the sweep switching bistable on A11 board through pin 17 and via MR3. The sense of the signal is such that when a delayed A+B mode is being displayed, the unblanking drive from VT4 is unaffected; but when a delayed B mode is being displayed the unblanking drive from VT4 is cut off.

Resistor R39 from the collector of VT9 (pin 6 to pin 15) adds a small proportion of blanking to the A unblanking drive signal on delayed sweep modes to indicate that the delaying trigger gate is open.

Current from the sweep switching bistable on A14 flows through R18 via pin 36. The voltage thus developed turns on VT5 producing a voltage waveform at test point 27 coincident with the unblanking drive period. Emitter follower VT6 passes this waveform out through pin 13, test point 28, to the A11 board. Emitter follower VT7 passes a fraction of the waveform at the collector of VT5 to the GATE OUT socket on the front panel of the A unit, via R27 and pin 10. R27 protects VT7 in the event of the GATE OUT socket being shorted to earth.

The triggered delay bistable VT8 and VT9 is similar to the basic bistable used elsewhere in the A and B sweep units. The bistable is only operative when the DELAY switch is in the VAR and TRIG positions. In the OFF position, the base of VT9 is connected to the +6.3 V line by the DELAY switch, via R36 and pin 3, biasing VT9 on. The purpose of the bistable is to provide a signal which will enable a triggered delayed B sweep to be produced by the B sweep unit. The output from the collector of VT9 (1G) is fed to the B sweep trigger gating circuits. When this signal is in its most positive state the trigger gate is commanded to close, when in its most negative state the gate is commanded to open. At the beginning of a delaying A sweep, VT8 is conducting and VT9 is cut off. A negative-going pulse from the variable delay pick-off circuit on board A11, is fed to the base of VT8 via pin 1, C11 and MR8. This signal turns off VT8 and the bistable action turns on VT9, whose collector goes to its most negative state, and so via pin 6 opens the B trigger gate. If the B sweep is triggered and runs and completes its run-up during the A sweep, a negative pulse coincident with the end of the B run-up is fed to the base of VT9 via pin 7, C10 and MR7. This pulse turns off VT9 and bistable action turns on VT8 thus completing one cycle of operation.

If the B sweep is not triggered or is triggered such that its run-up extends beyond the end of A run-up, a negative-going pulse coincident with the end of the A run-up is fed to the base of VT9 from the emitter of VT6, via C8 and MR6. This pulse then turns off VT9 and bistable action turns on VT8, thus completing one cycle of operation.

Board A11

Board A11 contains the sweep delay pick-off circuits consisting of a Schmitt circuit, a voltage comparator, a buffer stage, the sweep switching bistable (1XZ), several ancillary diode gates and the alternate bistable circuit.

The A sweep saw-tooth waveform is fed into pin 16, test point 17, to the base of VT1. This is an emitter follower stage which holds off the delay pick-off Schmitt circuit from the saw-tooth sweep out. The run-up is fed from the emitter of VT1

through MR1 and MR2, which limit the run-up waveform, to the Schmitt circuit, VT2 and VT3. Diodes MR1 and MR2 protect the input base of VT2 from an excessive voltage excursion. The Schmitt circuit is fed from a floating voltage supply developed across the Zener diode, MR3. The base of VT4 which is an emitter follower stage is connected to the wiper of the CM DELAY potentiometer through pin 18. The CM DELAY potentiometer therefore controls the voltage, relative to earth, at which the Schmitt circuit operates. Zener diode MR18 maintains a nearly constant voltage across R9 so that the operating conditions of the Schmitt circuit do not change excessively over the range of the CM DELAY potentiometer. Transistors VT5 and VT6 form a long-tailed pair and the d.c. output from the collector of VT5 to pin 13, is the voltage supply to the CM DELAY potentiometer. This voltage is maintained constant by coupling back to the base of VT5 through R12 and RV2. RV2 also calibrates the 9 cm delay point by adjusting the voltage at the collector of VT5. The 1 cm delay point is set up by adjustment of RV1 which, in series with R55, is taken through pin 7 of A10 to the CM DELAY potentiometer.

The action of the delay pick-off Schmitt produces a positive-going step at the collector of VT3, test point 18, which is differentiated by C5 and R19, thereby developing a pulse drive to the base of VT7. Transistor VT7 amplifies and inverts the pulse which is fed out from the collector via pin 34 to the B sweep and 1G bistable circuits.

The 1XZ sweep switching bistable, VT10 and VT11, is similar to the basic bistable circuit used elsewhere in the A and B sweep units but its collector loads. R26 and R35, are connected to +15 V instead of +6.3 V. The collectors of VT10 and VT11 are connected to the +6.3 V line by diodes MR6 and MR11, thus ensuring that the maximum positive-going excursion is nominally +7 V. The bistable is driven by a common input signal through C7 and C8. This signal is derived from either the A unblanking period (2A), the B unblanking period (2B), or the combined signal (2AB).

The 1XZ bistable is biased by the DISPLAY switch in the A+B position through R32 to the base of VT11, so that VT11 is turned on and VT10 turned off.

In DISPLAY B position, R29 biases VT10 on and VT11 off. Outputs are taken from both of the collectors of the 1XZ bistable; from VT10 to the emitter follower VT9 and out via pin 19, test point 20, and from VT11 collector to the base of the emitter VT13 and out via pin 5. The output from pin 19 is shown on the diagrams as $\overline{1XZ}$ and the output from pin 5 is shown on the circuit diagrams as 1XZ. The 1XZ signal is also fed to the base of VT14 which provides a current drive from its collector, test point 23, out via pin 4 to the vertical amplifier unit as the trace separation signal.

The 2A and 2B waveforms are fed into the A11 board via pin 23 and 22 respectively, and are added in a diode OR gate consisting of MR4, MR5 and R22. The output of the OR gate is fed to the base of the emitter follower VT8, and then out via test point 21, through pin 26. This signal is also fed into an AND gate, consisting of MR7, MR8 and R36 and an OR gate consisting of MR12, MR13 and R37. These two gates are operated by a command from the DISPLAY switch to MR7 and MR12, via pin 27, earthing pin 27 in the A+B and B positions. This routes the 2A, 2B or 2AB signal so that it operates the 1XZ bistable in the DISPLAY ALT position, but bypasses the bistable in the A+B and B positions. In the latter case, the signal is fed from the junction of MR12 and MR13 through MR14 to the base of the emitter follower VT12. From the emitter of VT12, test point 22, the signal drives the alternate bistable.

When the 1XZ bistable is being driven by either 2A, 2B or 2AB, i.e. in DISPLAY ALT position, the alternate bistable is triggered from the 1XZ output signal via C11, MR15 and VT12. The alternate bistable VT15 and VT16 is driven either by 2A, 2B or 2AB in the DISPLAY A+B or B positions, or by the 1XZ signal in the DISPLAY ALT position. One output only is taken from the collector of VT16 to the base of VT17 which provides the alternate current drive signal to the vertical amplifier, via test point 24, pin 20.

Board A14

The A14 board contains the sweep generator circuits which are sub-divided into the following stages; trigger gate, sweep start bistable, retrace trigger lockout gate drive circuit, waiting point amplifier and the Miller run-up. Also the ancillary stages, sweep out buffer and the sweep start output pulser. The latter ancillary stage is only used when the A14 board is wired into an A sweep unit.

The trigger gate consists of an amplifier, VT2, whose base is coupled through R4, in parallel with MR1 to test point 8, pin 22. This input receives an external command signal which inhibits trigger pulses at VT2. These negative-going trigger pulses are fed into pin 23, test point 7, via C3 to the base of VT2. The output from the collector of VT2 is fed through C7 to one half of the centre tapped primary of a ferrite-cored transformer, T1.

A negative-going trigger pulse is fed via pin 19 and MR2 to the other half of the centre tapped primary of T1, in the DUAL sweep mode, to produce the first B sweep. This trigger connection is only used in the B sweep unit, the pulse being produced by the sweep start output pulser VT1 on the complementary board in the A sweep unit. The sweep start bistable waveform is fed to the base of VT1 which inverts and amplifies its positive-going edge. The period for which VT1 is turned on is controlled by the time constant of C5 and R9 in the emitter circuit. Thus a negative-going spike is produced at the collector, which is coupled out to pin 2, via C4.

The variably delayed B sweep is triggered by a negative-going trigger pulse fed to pin 20 and then through C1 and MR3 to the junction of MR2 and T1. This pulse is inhibited by a connection from the DELAY switch, via pin 21, which reverse biases MR3 in the TRIG and OFF positions. This part of A14 is only used in the B sweep unit.

Positive-going trigger pulses are coupled into the sweep start bistable, VT3 and VT5, through diode MR4. When the sweep circuit is waiting, MR4 is biased on by current flowing through R27 whilst VT3 is cut-off. The positive-going trigger pulse from T1 turns on VT3 and the bistable action turns off VT5. This produces a negative-going waveform at the collector of VT3, test point 10, which is clamped in its negative-going excursion by diode MR5. VT6, in series with the collector load R18 of VT5, provides a current drive signal from its collector, test point 11, via pin 9 to the appropriate unblanking control circuits. VT4, whose base is connected to the collector of VT5, provides a low impedance drive to VT3 and to the base of VT1, the sweep start output pulser.

The sweep start bistable waveform from test point 10, turns off the disconnect diode MR12 which allows the Miller run-up to start at the collector of VT11, test point 13. The slope of the run-up is determined by the range resistor and capacitor selected by the TIME/CM switch, circuit diagram A15. The junction of the selected range R and C is coupled to the base of V1 through pin 6, test point 12, and grid stopper R42. The cathode follower V1 holds off the base current of VT11 from the range resistors. A diode MR13 in series with the emitter of VT11, biases the base of the transistor to a required voltage level.

The retrace point is determined by the Miller run-up waveform being coupled back to the base of the sweep start bistable, VT5, via MR7 at the junction of R25 and R26. The sweep length is controlled by altering the voltage drop across R25 through adjustment of the LENGTH control, in series with R26, via pin 7. MR6, R23 and R24 bias VT5 when MR7 is non-conducting. The retrace trigger lock out gate drive circuit consists of MR8, VT7, VT8 and VT13. Its purpose is to disconnect the trigger path from the input to the sweep start bistable during the run-up and retrace periods. The sweep waveform is connected through MR8 to the emitter of VT8. When the Miller stage is waiting, VT8 is cut off, causing VT7 to be non-conducting. Current flows through R27 via the secondary of T1 and MR4 to the junction of R15 and R16. After the start of the sweep run-up, MR8 is disconnected as VT8 turns on, causing VT7 to conduct. VT7 saturates and a voltage level of approximately -20 V, at the collector of VT7, prevents triggers from reaching the sweep start bistable by reverse bypassing MR4. This voltage is determined by R30, R31 and R32. When retrace is almost completed, diode MR8 is turned on, cutting off VT8 and VT7. The rate at which the collector of VT7 is allowed to rise, is controlled by the discharge of the waiting capacitor (selected by the TIME/CM switch) via R20 and pin 28. This adds a pre-determined period to the end of the retrace before the diode MR4 is turned on, stopping triggering pulses from reaching the sweep start bistable until the Miller circuitry has completely reached a quiescent state.

Resistor R14 from pin 27 to test point 9 changes the bias at the base of VT3 turning it on when the TRACE FINDER button is pressed. This causes the bistable to free-run in conjunction with the Miller stage. Transistor VT13, whose base is connected to test point 9, inverts the retrace trigger lock out signal which is fed from its collector, via pin 26, to the appropriate A or B trigger gating circuit on board A16.

The waiting point amplifier, MR9, VT9 and VT10, maintains the quiescent voltage level nearly constant at test point 13. When the Miller stage is waiting, MR9 controls the voltage at the junction of R34 and R35 so that VT9 is turned on. The emitter supply voltage is derived from R40 and diodes MR11 and MR10 which are connected in series to the chassis. This provides a stable reference voltage for the waiting point amplifier; MR10 and MR11 compensate for the temperature co-efficients of MR9 and the base emitter junction of VT9. The collector of VT9 is connected to the base of VT10 which is also turned on. The collector of VT10 is coupled to the Miller stage base through MR12 and V1. Hence any change of voltage at the collector of VT11 is coupled back to the waiting point amplifier, which amplifies the change and compensates for it. At the start of the run up, the waiting point amplifier is dis-

connected from the Miller stage by the sweep start bistable transistor VT3. This shares a common collector load, R17, in series with the selected retrace resistor, with VT10 of the waiting point amplifier. Thus when VT3 turns on, MR12 is reverse biased. Also, through the coupling of the run up waveform, via MR9, to the junction of R34 and R35, VT9 and VT10 are cut-off shortly after the start of the run-up. Hence at the start of retrace when the sweep start bistable switches back to the waiting state, as VT10 is switched off, all the current flowing through the retrace resistor, in series with R17 and MR12, flows into the grid circuit of V1, test point 12. This current discharges the range capacitor at a rate determined by the retrace resistor as selected by the TIME/CM switch. When the retrace, at test point 13, has nearly reached its normal waiting potential, MR9 turns on thus allowing VT9, VT10 to regain control of the waiting point. C18 couples the retrace waveform directly to the emitter of VT10 assisting the turning on of VT10 on the fastest sweep ranges.

Transistor VT12 provides a reduced amplitude saw-tooth waveform, taken from test point 13, via R47 and R48, to the front panel as a sweep out signal. R51 protects VT12, if the SWEEP OUT socket is shorted to earth.

Board A16

This board contains the trigger gating circuit and the aiming potential emitter follower circuit. The input signals to the trigger gating circuits depend on which sweep unit the board is wired to. These inputs are clearly shown on circuit diagram Fig. 7.12.

Diodes MR1 and MR2 form an OR gate and MR3 and MR5 form a diode AND gate. The combined outputs of these two gates is fed to a diode OR gate consisting of MR4, MR6, MR7 and MR8. The output from this OR gate is fed to the base of emitter follower VT1 and out to the A or B sweep trigger gate via pin 1, test point 14. The switching levels of the gates are nominally 0 V to +6 V.

The aiming potential emitter follower circuit consists of VT2, VT3 and VT4. VT2 provides a low impedance voltage supply to the range resistor selected by the TIME/CM switch through pin 3, test point 15. The base of VT2 is driven from the emitter of VT3, an emitter follower, which is controlled by the d. c. voltage applied to its base from the TIME/CM calibration potentiometers RV1 - RV5. The front panel VARIABLE TIME/CM control and R15 are in series with the TIME/CM calibration potentiometers as selected by the range switch, see Fig. 7.10. VT4 forms a constant current tail for VT3.

Board A17

This board contains the high level sweep gating and B unit unblanking generator circuits.

The high level sweep gates consist of diodes MR1, MR3 and transistor VT1 in the A gate and diodes MR2, MR4 and transistor VT2 in the B sweep gate. The sweep gating is performed at the collector of the transistor VT1 or VT2. Since the operation of the two sweep gates is identical, the following description of the A gate may be applied to the B sweep gate.

The gate transistor VT1 is turned on by a control signal applied to pin 27 via the resistor network R1, R3 to the base of VT1. The stage is driven into saturation. The sweep input is applied to pin 25, test point 17 and its waiting potentiometer is several volts more positive than the saturated transistor. Hence diode MR1 is non-conducting, so no sweep waveform appears at the collector of VT1. When the control voltage at pin 27 is reduced to approximately 0 V, VT1 is cut-off and its collector potential rises until MR1 conducts and clamps it relative to the applied input voltage at test point 17. The collector of VT1 now follows the voltage waveform applied to this test point. The B sweep gate is operated by the inverse control signal to the A sweep gate, so that when one is open the other is closed. The output voltage at test point 19 is determined by whichever gate is open through diodes MR3 and MR4. The output is taken from pin 22 to the input of the horizontal amplifier board, A13.

The B unit unblanking generator is very similar to the A unblanking generator on board A10, consisting of diodes MR5, MR6, MR7 and transistors VT3, VT4, VT5 and VT6. The unblanking generator drive transistor, VT3, provides a current drive to the unblanking amplifier through MR7 to pin 36, test point 20. The current drive is controlled through a connection from the base of VT3 to the A & B INTENSITY control via pin 14. VT3 also forms the collector load for one half of the sweep start bistable on board A14, via R12 and pin 12. When the sweep run-up is being produced no current is drawn from pin 12 into the collector circuit of the sweep start bistable, so that any collector current flowing in VT3 is passed through MR7 to the unblanking amplifier as an intensity drive signal. When the run-up has been completed, collector current for the sweep start bistable is

drawn from pin 12, thus removing the unblanking drive from MR7. MR6 clamps the maximum negative potential of the collector of VT3 to approximately -0.7 V. VT3 is controlled in the alternate delayed sweep modes by a signal ($\overline{1XZ}$) from the sweep switching bistable on A11 through pin 32 and via MR5 and R9. The sense of the signal is such that when a delayed A+B mode is being displayed, the unblanking drive from VT3 is reduced to give a lesser B unblanking signal which is added to the A unblanking drive at the input to the unblanking amplifier. In all other modes, the signal to pin 32 is reduced so that it has no effect on VT3.

Current from the sweep switching bistables on A14 flows through R12 via pin 12. The voltage thus deveoped turns on VT4 producing a voltage waveform at pin 21 coincident with the unblanking drive period. Emitter follower, VT5. passes this waveform out through pin 19 to the A or single sweep unit.

Emitter follower, VT6, passes a fraction of the waveform at the collector of VT4 to the GATE OUT socket on the B unit front panel via R22 and pin 3. R22 protects VT6 in the event of the GATE OUT socket being shorted to earth.

Board A18

The A18 board contains the single sweep bistable and the alternate drive bistable. The single sweep bistable consists of VT2 and VT3. In the NORM position of the SWEEP switch, VT3 is biased on and the RESET light is disconnected from its supply voltage by the SWEEP switch. In the SINGLE position of the SWEEP switch, the bistable is operated by pressing the RESET button, which turns off VT2 and the bistable action turns on VT3. VT1 is turned on when VT2 is cut-off and since the SWEEP switch is in the SINGLE position the RESET light is illuminated. The output from the collector of VT3 through pin 8, test point 1, is turned to its most negative state opening the trigger gate to the B unit. When B sweep is triggered and runs, a negative-going pulse coincident with the end of the B sweep run-up, is fed to the base of VT3 via pin 10, test point 2, and C6 in series with MR2. This pulse turns off VT3. VT2 is turned on by the bistable action, extinguishing the RESET light via VT1 and closing the trigger gate to the B unit.

The alternate drive bistable provides a current drive signal to the vertical amplifier for alternate dual trace unit use. The circuit consists of VT4 and VT5; it is driven by a negative-going edge, coincident with the end of the B sweep run-up via test point 2, pin 10. The bistable is wired as a ÷ 2 circuit so that it changes state at the end of each B sweep run-up. The output from the collector, provides a current drive signal via pin 16 to the vertical amplifier.

3.6 HORIZONTAL AMPLIFIER

Board A13

The 20 V sweep signal is fed via pin 6, test point 22, through emitter follower VT3 to be current mixed through R10 and MR1 at the virtual earth potential of VT5 base. Similarly, the external input enters via pin 10, through the protection circuit C2 and R55, the emitter followers VT1, VT2 and then current mixed via R8 at the base of VT5. Coarse and fine shift potentials are fed, via pins 18 and 17 respectively, to be current mixed via R4 and R3. Normally MR1 is conductive but in extreme negative positions of the shift controls, the diode cuts off. This prevents reverse drive of test point 23 via R11 occurring if VT5 is cut off. VT4 produces a constant current through R12 to bias VT5 to its correct point. VT4 also prevents any unwanted signals, from the -15 V line, reaching the sweep signal. VT5 is a shunt feedback stage producing a negative-going voltage waveform, at test point 23, which is a combination of sweep signal, shift potential and any external input.

The series stage VT6 and VT7 has the x1, x5 and x10 GAIN control switching network between their emitters. R41 and C7 form an h.f. lift network so that the 5 ns/cm sweep is more accurately displayed. RV1 and RV2 enable the x5 and x10 GAIN positions to be equalized with the x1 position. The signal current leaves the collector of VT6 and is fed, via the clamping diodes MR3 and MR5, to the virtual earth potential at the base of VT9. Resistors R33, R29, R36 and R35 are proportioned so that MR3 and MR5 will cease to conduct at sweep extremities outside the display area of the c.r.t. When the TRACE FINDER button is pressed, R32 is switched in to limit the available drive whilst R29 and R36 are switched out to maintain the d.c. balance thus facilitating trace finding. Diodes MR2 and MR4 conduct only when MR3 or MR5 are non-conducting, therefore limiting the voltage excursion at this point under these conditions. This improves the linearity at fast sweep speeds. Diode MR6 prevents the shunting effects of R32 when the TRACE FINDER is not being used.

Emitter follower, VT8 produces VT9 emitter potential. VT9 is a shunt feedback stage producing a negative-going voltage at test point 24, which is

limited to the correct swing, which prevents overloading of the output stage. This output is applied to the base of VT10 which, with VT12, forms a phase splitter. VT11 provides a constant current tail for VT10; and RV4 enables the x1 GAIN position to be set, R51, R52 and R53 form a bias chain for this stage. The balanced signal currents leaving the collectors of VT10 and VT12 are connected to the emitters of VT3 and VT4 on the main frame (see A0 on Fig. 7.1), via a pair of terminated 50 Ω coaxial lines. VT3 and VT4 have R2 and R3 compensated by L1 as their collector loads. This output stage, VT3, VT4 and associated circuitry, is situated very close to the horizontal deflection plates so that capacitive loading is minimized.

3.7 CALIBRATOR AND SUPPLY LIGHT CONTROL

Board A19

The supply light control circuitry has three modes of operation; mains input normal, i.e. ±10%, mains input more than 10% high, and mains input more than 10% low.

The +45 V reservoir capacitor, C4, on board A5, is at +60 V when a nominal mains input is applied. C4 is connected, via pin 18 on board A19, to RV1 which is set so that a ±10% change to the +60 V moves the base of VT1 approximately ±3 V around a nominal -1.5 V. Under normal input conditions, VT1 conducts and VT2 is cut off, biasing MR3 into conduction by means of R7. This cuts off VT3 leaving VT4 conducting due to base current through R12. This provides base current to VT5, via R14, which saturates the transistor thereby applying 6 V to ILP1 (on A0, Fig. 7.1) the POWER ON light.

If the mains input is low, VT1 base is taken lower than the base of VT2, thus VT2 is turned on and VT1 cuts off. The current through VT2 is sufficient to produce a voltage drop across R7 large enough to reverse bias MR3. VT3 and VT4 act as a free running multivibrator with a high off to on ratio. The repetition rate is low since the voltage at the junction of R5 and R6 is at its most positive and therefore the voltage across R12 is at a minimum. VT4 drives the indicator light via the buffer VT5 as described above.

When the mains input is high, the base of VT1 is taken more positive, approximately 1.5 V. MR1 will conduct and VT1 will conduct heavily and reach saturation. MR2 then conducts, pulling test point 1 to near zero volts and reverse biasing MR3. VT3 and VT4 act as a multivibrator, as described above. Since VT1 is saturated (the potential at the junction of R5 and R6 is much more negative) the voltage across R12 is greater. This shortens the 'off' time therefore increasing the repetition rate of the multivibrator making the on to off ratio nearer to unity.

Transistors VT6 and VT7 form a multi vibrator circuit operating at a pulse repetition frequency of 1 kHz. The emitter current through VT7 is fed into the base of VT8, thus when VT7 is conducting, VT8 is saturated. This determines the lower level of the calibration signal. When VT7 is cut off, VT8 is cut off and the precision Zener diode, MR5, clamps the potential at the collector of VT8 to 6.6 V ±5%, the upper calibration level.

RV2 sets the CALIBRATOR output to exactly 3 V whilst precision resistors R26, R27 and R28 produce the 300 mV and the 30 mV calibration signal used on the x1 and x10 internal CAL positions. R25 shunts these resistors so that when RV2 is set correctly, 6 mA p-p flows through the CALIBRATOR loop. Diode MR4 balances the voltage drop due to VT8, thus producing nominally equal mark to space ratios and also ensures that the 6 V switching signal does not break down the reverse base-emitter voltage of VT6. Pins B, E and A provide initial calibration points.

3.8 CATHODE RAY TUBE CIRCUITRY

Board A1

Transistors VT1, VT2 and VT3 form the main unblanking amplifier. VT1 is a grounded base stage and can be driven by one or more of four signals: A sweep unblanking, B sweep unblanking, chopped blanking or external unblanking. The composite signal at the collector of VT1 is fed to VT2 and VT3, which form a cascode stage. The unblanking signal developed across R12 is a.c. coupled onto the c.r.t. grid via C8 and R16, thus the high frequency components of the unblanking signal are fed onto the c.r.t. grid directly. The low frequency components are fed out to the e.h.t. unit via R15, modulated, then d.c. restored at cathode potential and returned to board A1, via pin 34, onto the c.r.t. grid via R16. Any unwanted modulator signal are filtered out by the integrating action of R16 and C8. Diodes MR1, MR2 and MR3 form a catching circuit which ensures that VT3 cannot saturate during full conduction, thus eliminating hole storage effects. C2 and C5 form a compensating circuit which improves the h.f. response of the unblanking amplifier. C5 is adjusted for minimum overshoot on the c.r.t. display.

4.6.4 B sweep run-up

Set the B sweep SOURCE switch to INT. Connect the marker generator to CH1 input and check all ranges on the TIME/CM switch for accuracy between the 1 cm and 9 cm vertical graticule lines. Set the TIME/CM switch to 1 ms/cm and adjust the marker generator to a 1 ms repetition rate. Turn the VARIABLE TIME/CM control fully counter clockwise (the UNCAL light should glow) and check that a minimum of five pulses per 2 cm are displayed, i.e. velocity ratio $\leq$ 2.5:1. Set the VARIABLE control to its CAL position.

Turn the preset LENGTH control fully counter clockwise and with the start of the trace on the extreme left vertical graticule line, check that the length of the trace is less than 10 cm. Note how many cm the trace is short of the 10 cm graticule line, i.e. the extreme right vertical line. Reset the trace length to the 10 cm line by means of the preset and, using the horizontal POSITION controls, move the end of the trace to the centre line. Turn the LENGTH control fully clockwise and note the increase in trace length to the right of the centre line. Add this to the previous reading and the overall change in length should be greater than 6 cm. Reset overall trace length to 10 cm.

4.6.5 Outputs

Using an oscilloscope check that the GATE OUT and SWEEP OUT signals are correct. See Fig. 4.5 for typical waveforms.

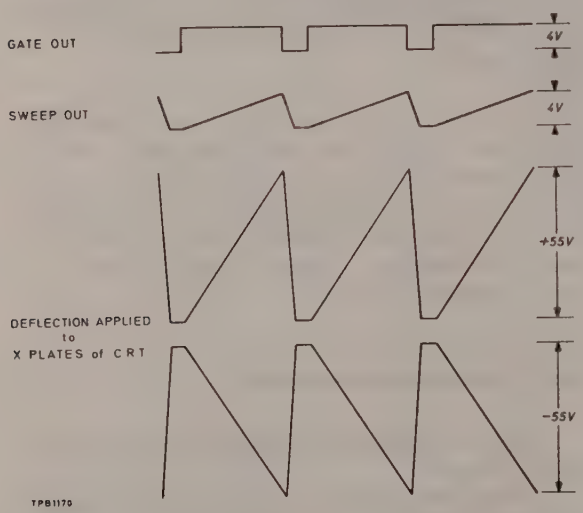


Fig. 4.5 · Typical front panel outputs

4.6.6 Horizontal amplifier

Turn both horizontal POSITION controls fully clockwise. Check that the start of the trace moves beyond the centre vertical graticule line. Turn the POSITION controls fully counter clockwise and the end of the trace should move to the left of the centre line.

Set the POSITION controls so that a marker pulse coincides with the centre graticule line. Set the horizontal MAG switch to x10 and check that the sixth marker does not move more than ±1 cm from the centre line. Set the MAG switch to x1, x5 and x10 and check, in turn, that the markers are 1, 5 and 10 cm apart respectively using the POSITION control as required. Check that the MAG light glows in the x5 and x10 positions.

Remove the marker generator from CH1 input. Set the B sweep unit SOURCE switch to EXT (to prevent a B sweep run-up). Apply a 1 kHz sinusoidal signal (5 - 10 V p-p) to the INPUT socket of the horizontal amplifier. Check that the deflection sensitivity at the INPUT socket is 1 V/cm.

Set the B sweep unit SOURCE switch to INT.

4.6.7 A sweep run-up

Set the A sweep DISPLAY switch to A+B and the SOURCE switch to INT.

Carry out checks as described under B sweep run-up.

4.6.8 CM DELAY control

Connect the marker generator to the CH1 input set to a repetition rate of 1 ms. Adjust the CH1 VOLTS/CM switch to give a 3 to 4 cm display. Set the A sweep trigger switch to AC and adjust the triggering controls to give a stable display. Set the B sweep TIME/CM switch to 50 μs/cm and set the A sweep DELAY switch to VAR. Adjust the CM DELAY to read 1.0 cm and the INTENSITY controls so that an intensified B sweep appears on the A trace. Check that the start of the B portion can be adjusted, by means of the CM DELAY, from 0.5 cm from the start of the A trace to the eleventh marker, i.e. 10 cm from the start of the trace. Note that the start of the brightened portion coincides with the appropriate CM DELAY reading on the multi-turn potentiometer.

4.6 PERFORMANCE CHECKS

Test equipment required

Item

a Marker generator 0.5 V output, range 0.1 μs - 1.0 sec switchable in 1-2-5 sequence.

b Sine wave generator 1 kHz 50 mV p-p. TF 1101.

c High impedance voltmeter 0.1% accuracy 0 - 10 V.

d General purpose oscilloscope 10 MHz bandwidth TF 2200 series.

4.6.1 Preliminary procedure

Set the front panel controls as follows:

Dual trace unit

DISPLAY switch to CH1
VOLTS/CM switch to CAL
VARIABLE VOLTS/CM control to CAL
TRIGGER switch to CH1
GAIN switch to x1
VERTICAL POSITION to midway
POLARITY switch to NORMAL

A sweep unit

DISPLAY switch to A+B
DELAY switch to OFF
SWEEP switch to NORM
TIME/CM switch to 1 ms/cm
VARIABLE TIME/CM control to CAL
AUTO-DC-AC switch to AUTO
SLOPE switch to +
SOURCE switch to INT

B sweep horizontal amplifier

FINE and coarse POSITION controls to midway
MAG switch to x1

If there is no trace on the screen press the TRACE FINDER button and adjust the INTENSITY control until a trace is clearly seen. Adjust the VERTICAL POSITION control so that the trace is centred on the screen. Release the TRACE FINDER button.

With the controls set as above, the internal cal signal (square wave) should be displayed filling the graticule area in the vertical direction. The following checks may now be carried out.

4.6.2 A sweep unit triggering

The cal signal displayed should be triggered on a positive-going edge of the waveform. Change the SLOPE switch to - and note that the signal is triggered from a negative-going edge.

Set the trigger switch from AUTO to DC and the SLOPE switch to +. If no trace is visible, adjust the LEVEL control until the sweep triggers. Check that the LEVEL control enables the signal to be triggered along the positive-going edge.

Adjust the triggering point to be on the horizontal centre line of the graticule with the LEVEL control. Adjust the CH1 DC OFFSET (screwdriver slot) control so that the waveform moves about the centre line and note that the triggering point remains on the horizontal centre line.

Set the trigger switch to AC and repeat the above noting that when the CH1 DC OFFSET control is adjusted the triggering point remains in the same position on the waveform.

Set the CH1 input selector to AC and the VOLTS/CM switch to give approximately 3 cm deflection when a supply frequency signal is applied to the CH1 input socket.

Set the SOURCE switch to LINE and the TIME/CM switch to a suitable range, e.g. 5 ms/cm. Ensure that the line signal can be triggered satisfactorily.

Remove the line frequency signal from CH1 and connect a 1 kHz sine wave generator, with an output of not less than 100 mV p-p, into the CH1 input and to the EXT socket on the A sweep unit. Set the SOURCE switch to EXT and the TIME/CM switch to 1 ms/cm. Observe that the 1 kHz signal triggers correctly.

4.6.3 B sweep unit triggering

Set the A sweep unit DISPLAY switch to B.

Since the B sweep unit has identical trigger facilities, set the B sweep TIME/CM switch to 1 ms/cm and the VARIABLE control to CAL and carry out all the previous checks.

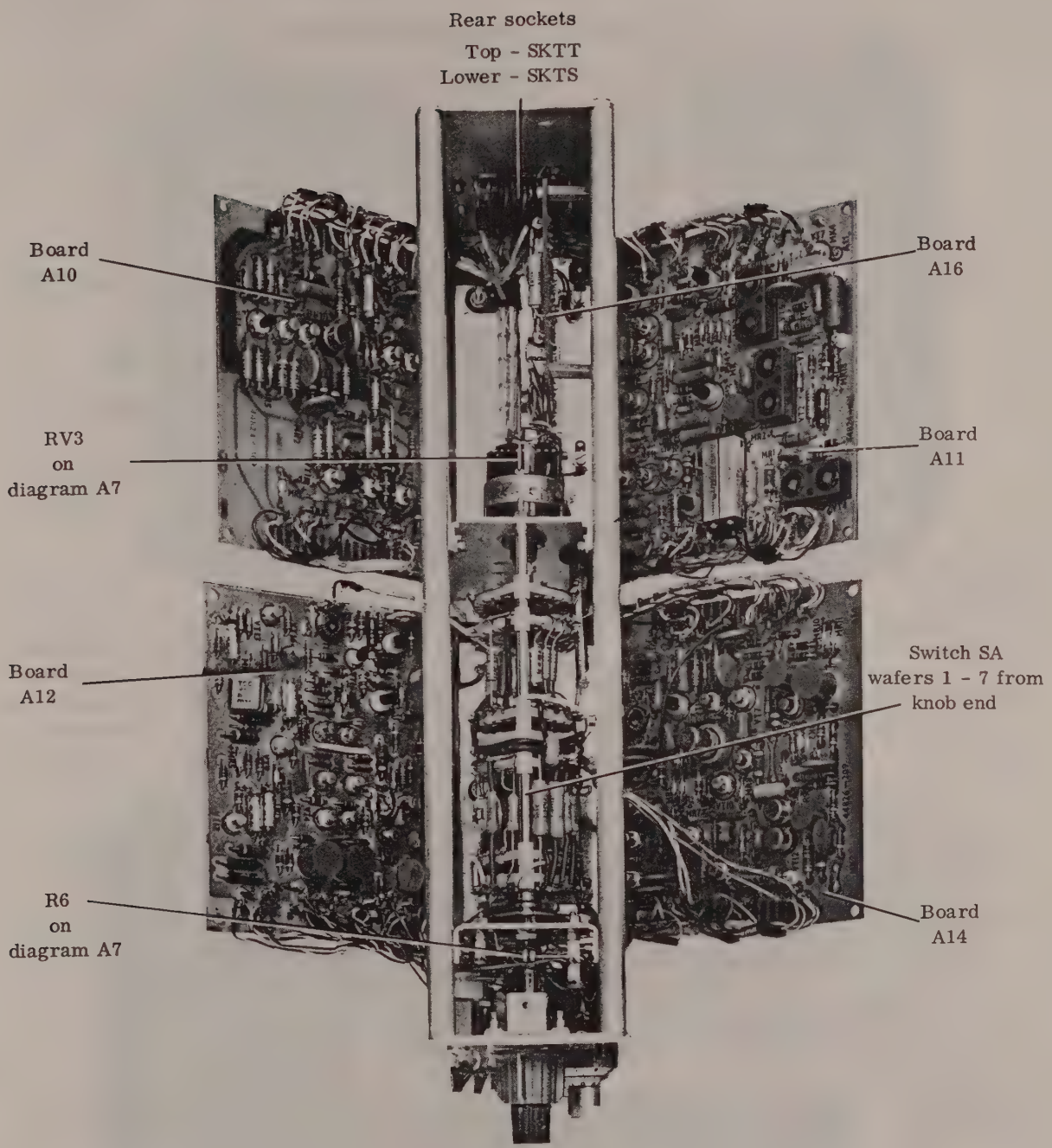


Fig. 4.4 A sweep unit with boards unhinged

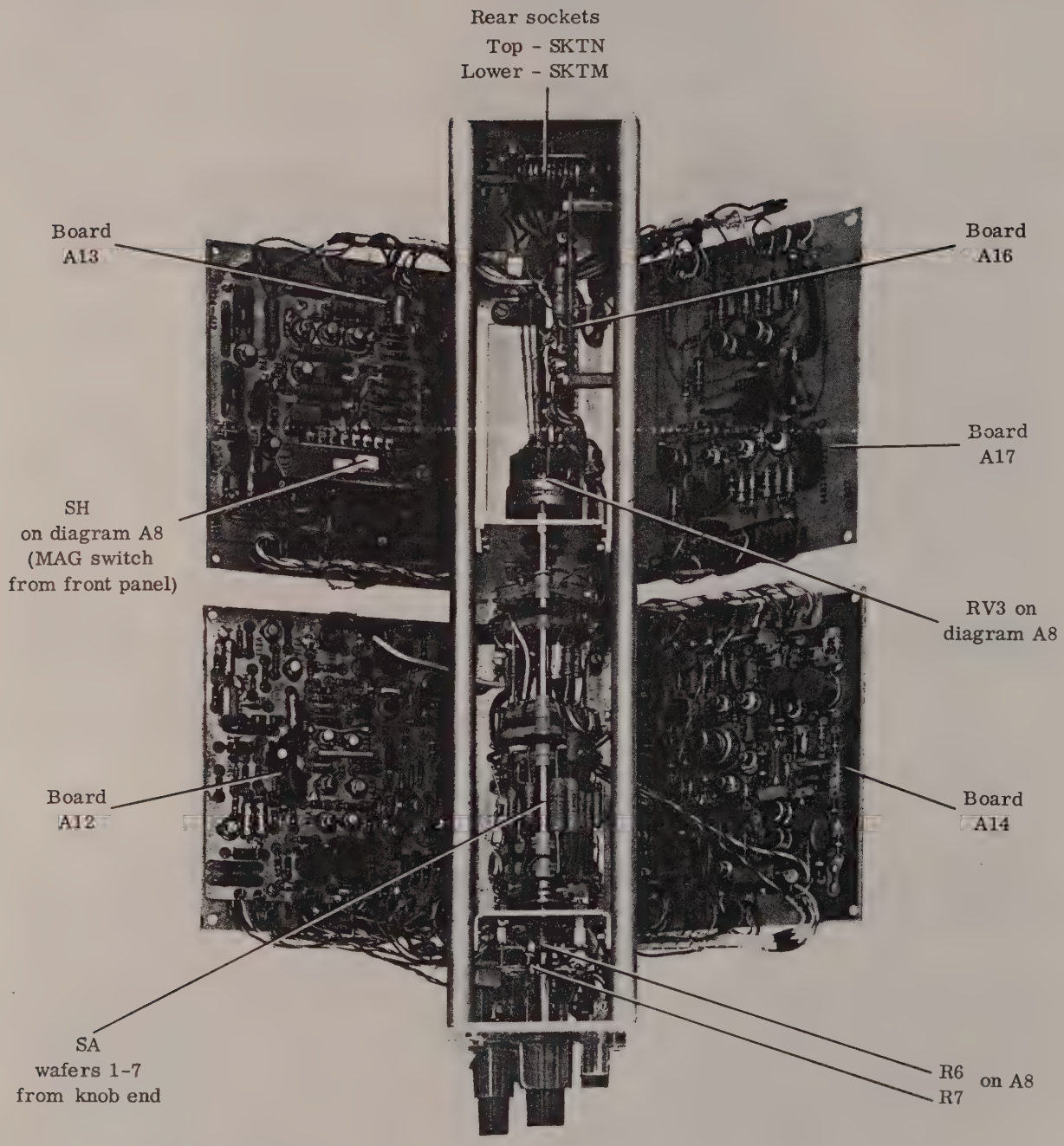


Fig. 4.3 B sweep unit with boards unhinged

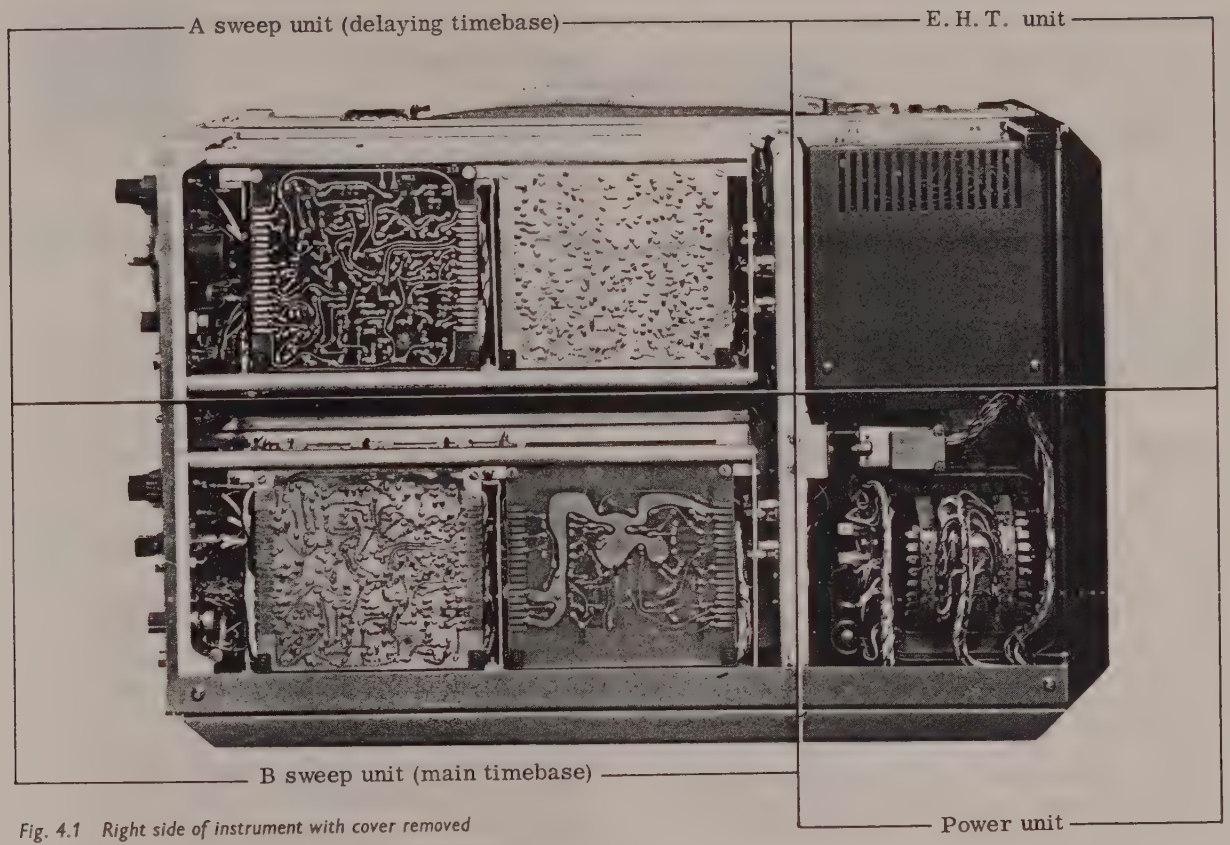


Fig. 4.1 Right side of instrument with cover removed

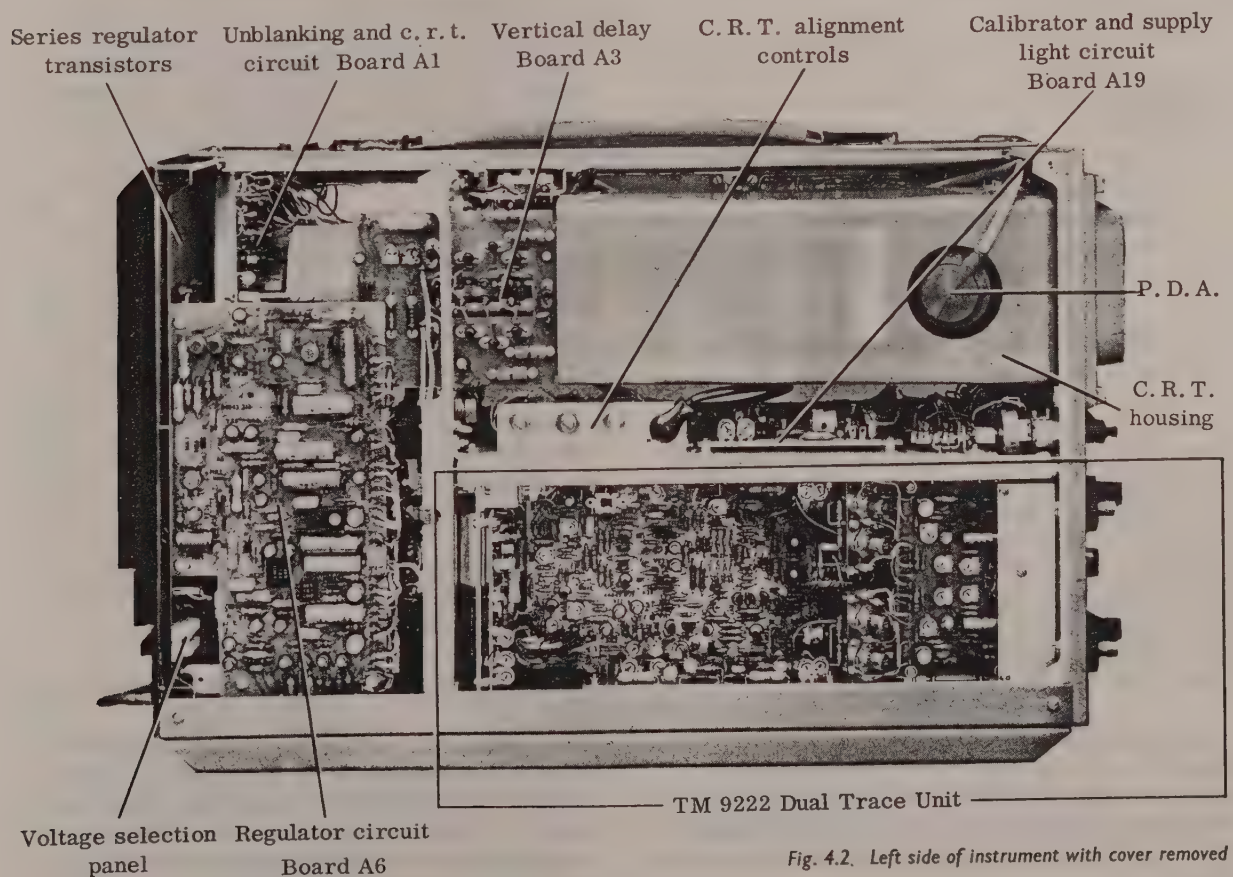

Series regulator transistors
Unblanking and c. r. t. circuit Board A1
Vertical delay Board A3
C. R. T. alignment controls
Calibrator and supply light circuit Board A19
P. D. A.
C. R. T. housing
TM 9222 Dual Trace Unit
Voltage selection panel
Regulator circuit Board A6

Fig. 4.2. Left side of instrument with cover removed

is obtained by removing the whole power unit assembly. By connecting SKTV and SKTX, the power and e.h.t. units may be operated whilst detached from the instrument.

To gain access to the pins of the lower pair of power transistors and the mains tapping panel, undo the six 4 BA Pozidriv screws on the right side of the rear panel and hinge the capacitor mounting assembly together with board A6 away from the rear panel. Access to the mains lead connections is gained in this way.

Cathode ray tube

Remove the bezel on the front panel by undoing the four knurled screws. Remove the scale light plate by loosening the plastic clip in the centre concealed by the foam strip. Remove the black plastic gasket and unscrew the four studs onto which the knurled screws were holding the front panel bezel. Lift off the sub-panel. It may be necessary to gently ease out the black rubber c.r.t. resilient mounting.

Disconnect the p.d.a. plug (PLW) on the side of the c.r.t. and the socket (SKTAA) at the left side of the instrument, adjacent to the c.r.t. alignment presets.

WARNING

The p.d.a. lead retains its charge for a considerable time after switch off and should be shorted to earth several times immediately after it is unplugged from the side of the c.r.t.

Disconnect the eleven tube deflection pins on the neck of the c.r.t.

With extreme care ease the cathode ray tube forward. It is essential that the deflection pins do not foul the metal c.r.t. shield on removal of the tube nor the felt pads around the inside of the shield. To avoid this, ensure that the c.r.t. remains concentric with the shield until clear of the instrument. Care must be taken not to foul the deflection coils on the cylinder around the c.r.t. particularly when replacing the tube.

Printed boards

The four main printed boards on each sweep unit hinge out on their cableform by unscrewing the two 6 BA cheesehead screws at the top of each board.

4.4 TEST POINTS

There are a number of test points on each printed board and their location may be ascertained from the circuit diagrams and from Sect. 5.2. Waveforms are shown on the circuit diagrams under normal operating conditions with the controls set as follows:

A sweep unit

TIME/CM switch to 10 μs/cm
VARIABLE TIME/CM control to its CAL position
DISPLAY switch to A+B
DELAY switch to VAR
SWEEP switch to NORM
CM DELAY control to 5.0 cm
AUTO-DC-AC switch to AUTO
SLOPE switch to +
SOURCE switch to INT

B sweep unit

TIME/CM switch to 1 μs/cm
VARIABLE TIME/CM control to its CAL position
Horizontal amplifier MAG switch to x1
AUTO-DC-AC switch to AUTO
SLOPE switch to +
SOURCE switch to INT

The waveforms were monitored and photographed on a TF 2210 oscilloscope. The sweep speeds and voltage reference levels are given with each oscillogram so that you will be able to obtain a representative waveform on your instrument.

The control positions vary for some waveforms and where this occurs the new control position is indicated. Also, some oscillograms were photographed with the particular sweep unit on extension leads, or with the monitoring oscilloscope on external triggering, this information is provided where applicable. The probe used to monitor the waveforms was an mi TM 8110 and when x10 attenuation was used it is indicated in the oscillogram summary on the circuit diagram, otherwise the probe was switched to x1.

Voltages were measured with a 20 kΩ/V meter. The relevant control settings are given against each circuit diagram.

4.5 LOCATION OF SUB-ASSEMBLIES

Figs. 4.1 and 4.2 show clearly how the plug-ins are situated in the oscilloscope, together with the location of other assemblies on the main frame. Figs. 4.3 and 4.4 show how the printed circuit boards on the sweep units can be hinged out for easy access and maintenance.

Chapter 4

Maintenance

4.1 INTRODUCTION

This chapter contains information for keeping the equipment in good working order and for checking its overall performance.

Before attempting any maintenance on the oscilloscope you are advised to read the preceding technical description chapter.

CAUTION

This instrument uses semiconductor devices which, although having inherent long term reliability and mechanical ruggedness are susceptible to damage by overloading, reversed polarity and excessive heat or radiation. Avoid hazards such as prolonged soldering, strong r.f. fields or other forms of radiation, use of insulation testers or accidentally applied short circuits. Even the leakage current from an unearthed soldering iron could cause trouble. Before shorting or breaking any circuit, refer to the circuit diagrams to establish the effect on bias arrangements of the transistor.

4.2 SCREW FASTENERS

Screw threads on this instrument are of the following sizes: 2 BA, 4 BA, 6 BA, 8 BA. The 2 BA, 4 BA and 6 BA chrome headed Pozidriv screws on the front and rear panels of the instrument are the only screws of this type in the oscilloscope. To avoid damaging them a Pozidriv screwdriver should be used. The remainder of the screw fasteners throughout the instrument are either slotted cheesehead type or hexagon headed, the latter being used in areas not accessible to a screwdriver. For either, the correct size of screwdriver or spanner should be used.

4.3 ACCESS AND REMOVAL OF UNITS

Removal of covers

Each side cover is held by two screws near the top at each end. Turn them until they become loose, then lift the panels off.

Removal of plug-ins

The A and single sweep plug-in units are held by a screw under the right-hand cover. This screw should be removed and the plug-in pulled gently out of the instrument.

The B plug-in unit is held in the instrument by one 6 BA screw under the front panel near the tilt bar.

E.H.T. unit

WARNING

Before attempting any work on the e.h.t. unit make sure that the mains supply is disconnected from the instrument. Detach the p.d.a. lead from the c.r.t. and short it to earth several times immediately it is unplugged.

This unit has a red coloured cover and is situated at the rear of the instrument on the right-hand side. To remove the unit, disconnect the printed board edge connector (SKTX) at the base of the e.h.t. assembly. Remove the two 4 BA cheesehead screws on the handle support bar adjacent to the INTENSITY MOD sockets and the four 4 BA Pozidriv screws in the top left side of the rear finned panel.

The e.h.t. unit may now be lifted out.

Power unit and rear panel

The power unit is mounted on the rear panel of the instrument. Disconnect the printed board edge connector socket (SKTX) and the socket (SKTV) immediately above the mains transformer. Undo the two cheesehead screws and the two 4 BA Pozidriv screws on the handle support bar near the INTENSITY MOD sockets. Unscrew the two 4 BA Pozidriv screws on each side on the standing runners and the three Pozidriv screws underneath the rear panel.

Slide the power unit complete with rear panel out from the main frame. The p.d.a. lead may be unplugged from the c.r.t. for complete removal. Access to the circuitry on the main frame bulkhead

for the c.r.t. cathode. V2 is a conventional series regulator and VT8 and VT9 form a constant current pair. The high output impedance of the latter ensures a small potential division from the c.r.t. cathode to the grid of V2, increasing the loop gain. The R-C network formed by C20, C21, C22 and R27, R28, R29, improves the phase response of the control loop and avoids 'ringing' following the application of a step function load. An additional 120 V is supplied by the 44 turn secondary winding and is rectified by MR8 and MR9. This voltage is then added to the c.r.t. cathode to provide the nominal -1.6 kV grid supply.

The grid voltage may be adjusted by RV1, the preset brightness control, which is situated within the e.h.t. unit. C10 feeds a portion of the voltage across the 44 turn winding to V2 anode, neutralizing the pulse developed at the earthy end of the 500 turn secondary. In a similar manner C19 neutralizes any c.r.t. heater voltage produced at the cathode by transformer T1.

Wound onto the subsidiary primary is the 2500 turn secondary and the voltage induced in it rectified by V1 and fed to the final anode of the c.r.t. Owing to the tuning, the pulse across this winding has a single peak, wheras the main primary winding has a double humped waveform. The heater voltage for V1 is provided by a single turn around the transformer core.

Unblanking signals from pin 15 (board A1) are fed into the emitter of VT7. The emitter is also driven from a 2 turn winding on T2 via MR7 which blocks any positive excursions of the pulse. These pulses drive VT7 into full conduction. The current during the interval between pulses is dependent upon the amplitude of unblanking. As a result, the signal at the collector (which is a.c. coupled via C13 and R26 to the c.r.t. grid) consists of the unblanking waveform modulated upon e.h.t. pulses. MR8 and MR9 conduct on the peak of the drive pulses and clamp the composite signal to the preset d.c. grid voltage during the interval. This restores the d.c. component of the unblanking signal and the unwanted e.h.t. components are prevented from reaching the c.r.t. grid by the integrating action of R26, C13, R16 and C8 on board A1. RV2 varies the gain of VT7 and balances the amplitude of signal reaching the c.r.t. from VT7 to that of the direct feed via C8 on board A1, thus ensuring zero waveform tilt.

Fault protection is afforded by trip transistors VT4, VT8, VT12, VT13, VT19 and VT23 operating, via MR5, on the bistable formed by VT26 and VT27. Normally, the line current flowing through the small series resistor develops a potential of about 300 mV which is not enough to turn the transistor on. At current levels in excess of twice this figure, the trip transistor will turn on and operate the bistable such that VT27 conducts. This action shuts down all the lines by reverse biasing emitter followers VT3, VT7, VT11, VT14, VT18 and VT22 via disconnect diodes MR1, MR2, MR3, MR9 and MR12 and resistor R56. Resistors are included in all the trip transistor bases and collectors to limit the base current when the lines are short circuited, as high transient voltages would be present across the current sensing resistors. C7 is included in the bistable circuit so that the trip circuit is rendered inoperative for a short time after switch on. This is necessary to allow smoothing capacitors C1, C2, C3, C11, C12, C13 and other capacitive line loading to charge without tripping the protective circuit.

In the event of a power supply failure, the trip can be rendered inoperative by shorting test point 5 to earth. The power supply may then be tested by slowly increasing the supply voltage by means of a variable transformer. If this technique is used, great care must be taken to increase the input very slowly, monitoring all the line currents in turn to check for excessive loading. Extensive damage may result if the unit is operated at normal mains input under fault conditions with the trip circuits inoperative.

3.11 E.H.T.

Basic system

E.H.T. is generated by switching the resonant circuit formed by the e.h.t. transformer across the +45 V line at an 18 kHz repetition rate. By clipping the resultant waveform after the first half cycle of operation, a pulse is obtained of about 5 . 1 mark/space ratio. Rectification of this, from the appropriate secondary windings, gives an unregulated +12 kV for the p.d.a. anode of the c.r.t., and a regulated -1.8 kV to provide -1.5 kV for the cathode. An additional winding and rectifier circuit supplies a variable 0 - 120 V which is added to the cathode to give a nominal -1.6 kV grid voltage. Interposed between the oscillator and the switching transistor is an intermediate stage and a transformer which generates the c.r.t. heater current. Signals from the unblanking amplifier are fed to the c.r.t. grid by two paths which are matched in gain to give zero distortion. High frequency components are a.c. coupled on board A1. The low frequency component of the signal is fed into the e.h.t. unit and modulated upon a carrier of e.h.t. pulses.

After a.c. coupling, the d.c. component is restored by clamping the pulse peaks to the c.r.t. grid potential thereby utilizing the diodes which also supply the grid bias. The composite waveform is then directly fed to the grid, the unwanted e.h.t. pulses being removed by double integration. Signal connection between the unblanking amplifier and the high voltage c.r.t. grid is thus achieved, whilst reserving the d.c. component.

Unit A2

VT1 and VT2 form a free running multivibrator providing a nominal 18 kHz square wave which is fed to the driver stage VT5, via the compound emitter follower VT3 and VT4. These provide sufficient base current to make VT5 bottom during conduction without loading the multivibrator. To ensure that the stage turns off rapidly, diodes MR3 and MR4 conduct as VT3 and VT4 cut off passing on the negative transition of the multivibrator to its base. Therefore VT5 is switched between full conduction and cut off. A square wave of approximately 40 V p-p is developed at its collector which drives the transformer T1. This has two secondary windings, one which delivers 6.3 V r.m.s. to the c.r.t. heater and the other drives the main e.h.t. switch VT6, via R11.

VT6 is normally held conducting for about 30 μs and then rapidly turned off. During the off period, a resonant waveform is obtained across the tuned circuit formed by the e.h.t. transformer T2 and associated circuitry. After the first half cycle of oscillation, MR5 conducts and prevents the collector of VT6 from going negative. The remaining energy stored in T2 is returned to the h.t. line via MR5, improving the efficiency of the stage. The collector waveform would normally take the form of a positive-going half sine wave of approximately 350 V peak, but the leakage inductance of T2 is tuned to give an increase of e.h.t. voltage over that obtained merely by the turns ratio. To facilitate this, two primaries are wound on opposite halves of the transformer core, one is connected directly to VT6 collector, the other coupled by L2. The tuning (and therefore the efficiency of the stage) is varied by L2. The effect of the tuning is to give a double humped appearance to the pulse across the main primary and its associated secondary windings. Of these the 500 turn winding provides approximately 1.8 kV, after rectification by MR6, C11. This voltage is then regulated by V2, VT8 and VT9 to give -1.5 kV

3.9 VERTICAL DELAY

Board A3

This board carries the circuitry to couple the output of the vertical amplifier to the distributed deflection system in the c.r.t.

Circuit analysis

VT1 and VT2 (A0) are emitter followers biased by R2 and R3 to produce the +60 V mean plate potential required. R1 minimizes the power dissipated in the transistors whilst C2 prevents any oscillations occurring in this stage and C1 keeps the impedance at the emitter low at high frequencies. Inductors L2 to L9 are adjustable centre tapped coils which, together with plate capacitance, form a balanced transmission line terminated by resistors R4 to R7. L1 compensates for the capacitance across these resistors.

The balanced current feed from SKG and SKF is shunted by R8, R9, RV1 and RV2 (selected by links 12 - 13, 14 - 15) to allow for tube sensitivity tolerances, the remainder passing through the transmission line to produce vertical deflection in the c.r.t.

3.10 POWER SUPPLY

Basic system

The detachable mains driven power unit provides stabilized lines of +153 V, +110 V, +45 V, +15 V, +6.3 V, -15 V and -45 V by means of series regulators driven by long-tailed pair comparators. The -45 V line is referred to a stable Zener diode and all the other lines are referred back to the -45 V line. Each line, with the exception of the +153 V line, which has a very small power capability, contains a load current sensing resistor. This resistor is so proportioned that the voltage across it is adequate to turn on a transistor if the load current exceeds twice the normal level. If this occurs, the collector current in this transistor operates a bistable which cuts off all the series regulators causing a complete shut down of the power supply.

To reset the power supply, it is only necessary to turn the POWER ON switch off and then on. The power supply should then operate normally if the overload has been removed otherwise it will trip out again.

The e.h.t. potentials are generated in a subassembly mounted on the power supply. This unit is described in Sect. 3.10.

Board A4 and Unit A5

The mains supply is fed via FS1 and SKV to SB (on A20), back to SKT and via the voltage selection panel to T1, the mains transformer. Output windings on T1 feed a.c. to the bridge rectifiers MR2 to MR21 which feed d.c. to reservoir capacitors C2 to C6. A centre tapped winding is used (via MR22, MR23) to feed the +6.3 V line reservoir C7, because of the high current to voltage ratio in this line. Resistors R1 to R6 discharge the reservoir capacitors after switch off. VT1 to VT6 are the series regulators for each of the lines indicated in the basic system and are shown in the circuit diagram Fig. 7.3.

Output winding LT1 feeds low voltage a.c., via FS2, to pin 12 on SKV. This feeds the graticule illumination circuitry on A0. The output potentials on pins 26 and 28 of SKV (from potential dividers R7, R9 and R8, R10) provide supply frequency triggering in the LINE position of the SOURCE switch on the A and B sweep units. Also, the voltage at the LT1 tap drives half wave rectifiers MR24 to produce a -6.3 V unregulated line across C8 to operate the trip on the A6 board when the unit has shut down.

Winding HT4 drives MR1 producing a potential across C1 which is added to the +110 V line and regulated by a 43 V Zener diode on A6 to produce a low current +153 V line for the c.r.t. supplies.

Board A6

MR13 is a low temperature-coefficient Zener reference diode. VT24 and VT25 form a long-tailed pair which compares the reference voltage with that at the slider of RV1. Resistors R64 and R65 are so proportioned that this potential is -6.6 V when the -45 V line is at the correct value. RV1 allows adjustment for the tolerance of the Zener voltage whilst R77 makes the resistance seen by the base of VT25 the same as that seen by VT24. This minimizes the effect of transistor current gain change with temperature. Any error on the -45 V line will thus unbalance the comparator and produce an output from the collector of VT25 which will correct the error when fed by the emitter follower VT22 to the series regulator V2 (on A5). C13 keeps the output impedance low at higher frequencies whilst MR14 prevents the line from being taken positive in the event of a short circuit to a positive line. The -15 V, +6.3 V, +15 V and +45 V lines are all similarly derived except that they are referred to the -45 V line instead of a separate Zener diode. The +110 V line is slightly different in that VT15 is included to limit the peak line current to a safe value.

4.6.9 Triggered delay mode

Set the CM DELAY control to read 0.5 cm and the DELAY switch to TRIG. Adjust the B sweep LEVEL control so that the B sweep intensified portion is triggered by the second marker. Increase the CM DELAY control noting that, as the delay approaches 1.0 cm, the B sweep jumps to the third marker and so on for each centimetre up to the eleventh marker.

4.6.10 Sweep modes

(i) Set the DISPLAY switch to A+B, the DELAY switch to OFF and the SWEEP switch to NORM. Select AC triggering and adjust the LEVEL control to give a stable A sweep. Set the DISPLAY switch to B and the B sweep TIME/CM switch to 1 ms/cm. Set the B triggering to AC and adjust the LEVEL control as above.

Set the DISPLAY to ALT and adjust the INTENSITY controls so that both traces are visible. Note that both the A and B traces will move together with adjustment of the CH1 POSITION control, and that the B sweep can be moved equally above and below the A sweep by means of the TRACE SEPARATION control.

(ii) Set the DISPLAY switch to A+B and the DELAY switch to VAR. Set the B sweep TIME/CM switch to 0.1 ms/cm and adjust the CM DELAY control to about its mid position. Adjustment of the INTENSITY controls may be necessary to see the B sweep clearly on the A sweep. Set the DISPLAY switch to B and check that, as the CM DELAY control is adjusted, magnified delayed marker pulses are displayed.

Set the DISPLAY switch to ALT and check that an A sweep with an intensified B sweep and the corresponding magnified B delayed sweep are displayed. Some readjustment of the INTENSITY controls may be necessary.

(iii) Set the DISPLAY switch to A+B and the DELAY switch to TRIG. Set the CM DELAY control to its mid position. Adjust the B sweep LEVEL control to obtain a B intensified portion on the A sweep, triggered by one of the marker pulses. Repeat the checks described above (ii) for the VAR delayed mode but noting that now the brightened portion jumps from pulse to pulse as the CM DELAY control is adjusted.

(iv) Set the DISPLAY switch to A+B and the DELAY switch to VAR. Set the SWEEP switch to DUAL and adjust the CM DELAY control to about 5 cm. Check that a B intensified period is displayed at the start of the sweep and a second period displayed at about 5 cm from the start of the A sweep.

The second B period is adjusted with the CM DELAY control as for VAR delay (described in (ii)). Set the DISPLAY switch to B and check that two magnified marker pulses are displayed superimposed and that one is moved horizontally over the other as the CM DELAY is adjusted.

Set the DISPLAY switch to ALT and check that the A sweep with intensified B sweeps and magnified B sweeps are displayed. Note that if the second variably delayed sweep is moved up to the first B period, the delayed sweep ceases to run.

(v) Repeat the above checks with the DELAY switched to TRIG, see checks in part (iii).

4.6.11 Single sweep

(i) Set the DISPLAY switch to A+B, the DELAY switch to OFF and the SWEEP switch to NORM. Set the A and B sweep TIM/CM switches to 10 ms/cm and set the marker generator to 10 ms repetition rate. Adjust the A sweep trigger controls to obtain a stable display and turn the LEVEL control fully counter clockwise to stop the sweep from running. Set the SWEEP switch to SINGLE, press the RESET button and check that the light is illuminated. Adjust the A sweep until one A sweep is produced. Note that the light remains on until the sweep has been completed and that no further sweeps occur. Repeat the above, selecting the B position of the DISPLAY switch and by adjusting the B sweep LEVEL control.

(ii) Set the DISPLAY switch to A+B, the DELAY switch to VAR and the SWEEP switch to NORM. Adjust the CM DELAY control to about 5 cm and the B sweep TIME/CM switch to 1 ms/cm. Adjust the A sweep trigger control to obtain a stable display and the INTENSITY controls to give a brightened B portion on the trace. Turn the A sweep LEVEL control fully counter clockwise to stop the sweep. Set the SWEEP switch to SINGLE and press the RESET button. Check that the light is illuminated. Turn the LEVEL control slowly in a clockwise direction until the A+B sweep occurs. Note that the light remains on until the sweep has been completed and that no further sweeps occur.

Set the DISPLAY switch to B and repeat the above, noting that a delayed and magnified B sweep is displayed.

(iii) Set the DELAY switch to TRIG, the SWEEP switch to NORM and the DISPLAY switch to A+B. Adjust the A sweep trigger controls to obtain a stable display and the B sweep LEVEL control for a B intensified period triggered by one of the marker pulses. Repeat the checks as in part (ii).

4.7 CLEANING AND LUBRICATING

If it is necessary to clean the contacts of any rotary switches, this should be done with benzine or white spirit (not carbon tetracloride), and the contacts should afterwards be wiped with a suitable lubricant such as a 1% solution of petroleum jelly in white spirit. Avoid lubricants containing soap or solid materials.

Chapter 5

Repair

5.1 INTRODUCTION

This chapter is intended to help you to fault find and to carry out internal checks; use in conjunction with the circuit diagrams at the rear of this manual. Performance limits quoted are for guidance only and should not be taken as quaranteed performance specifications unless they are also quoted in the Data Summary section. Details of cover removal and access to printed boards etc. are explained in Chap. 4.

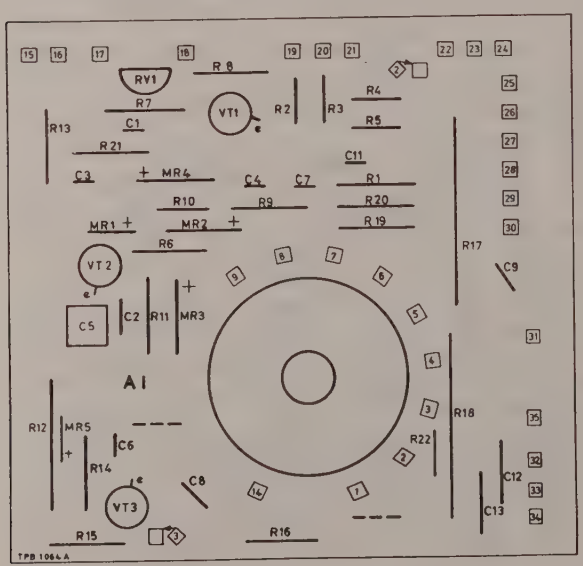
CAUTION

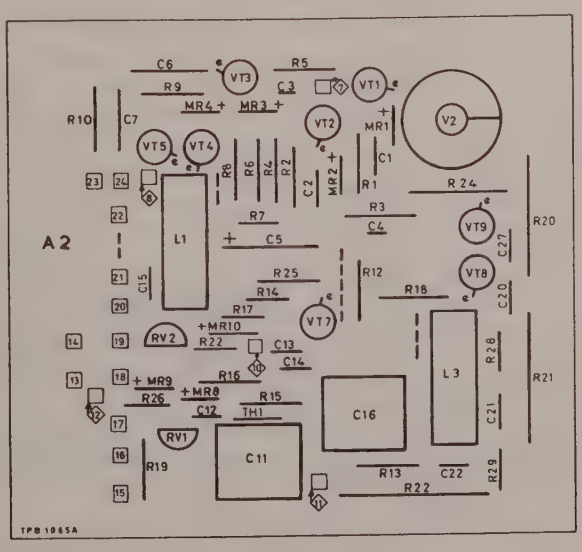
See Sect. 4.1 for precautions in handling semiconductors and Sect. 4.2 for advice on screw fasteners.

In case of any difficulty, please write or phone the Marconi Instruments Service Division (see address on back cover) or nearest representative, quoting the type and serial number on the data plate underneath the instrument. If the instrument is being returned for repair, please indicate clearly the nature of the fault or the work you require to be done.

5.2 COMPONENT LOCATION

There follows a legend diagram for each printed board in the oscilloscope which will be useful for precise location of any component.





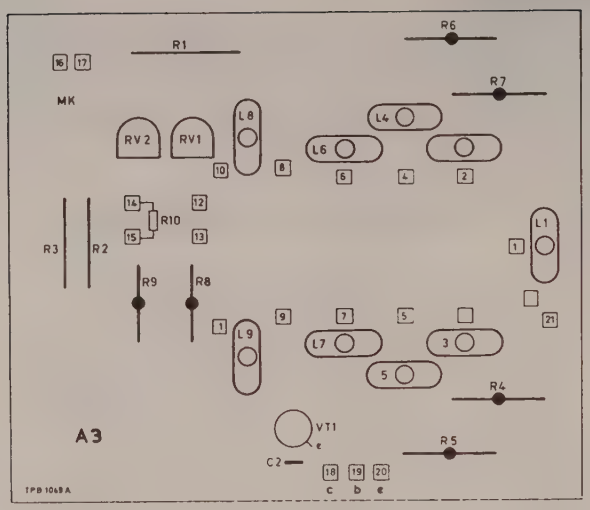
5.3 REPLACEMENT OF COMPONENTS

Nuvistors or transistors should not be replaced unless they are actually defective. If these components are removed from any printed board and found to be acceptable, they should be returned to their original socket. It is advisable not to use test equipment for checking transistors or nuvistors because the tester may fail to indicate a defect which will affect the performance of the circuit. It is therefore recommended that transistors or nuvistors are checked by a method of substitution. Unnecessary replacement of these components is expensive and may also result in needless recalibration of circuits.

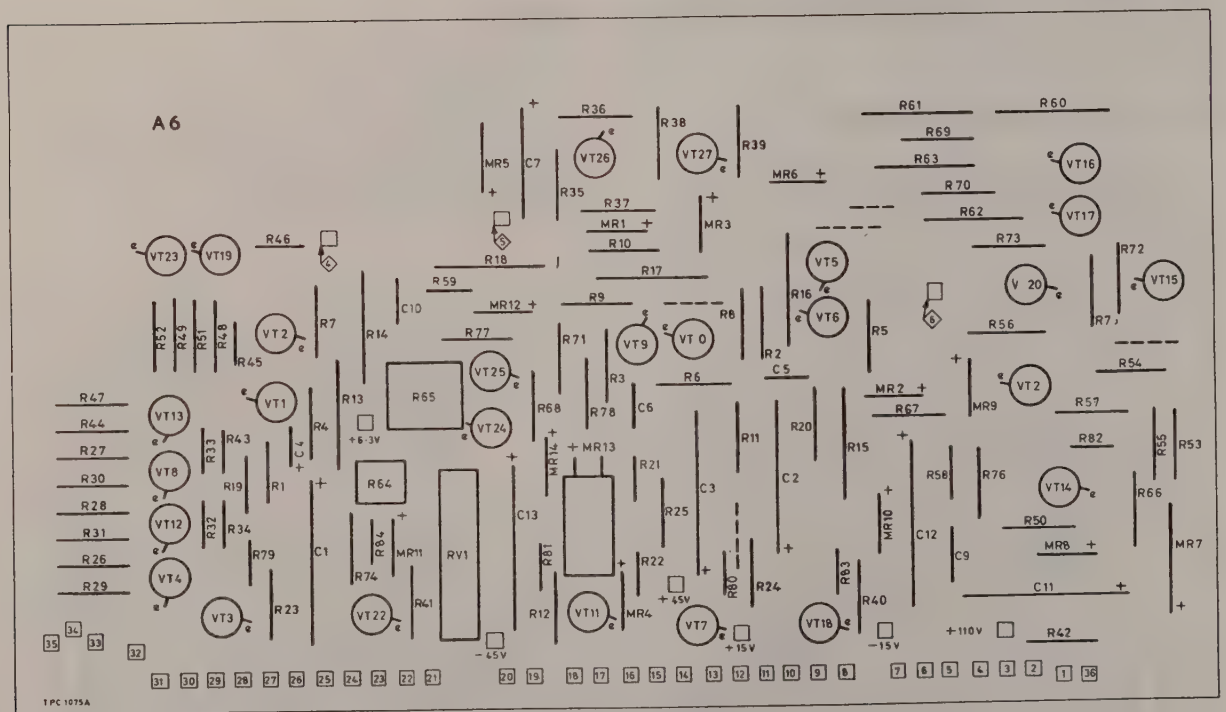
For precautions whilst replacing semiconductor devices see Sect. 4.1.

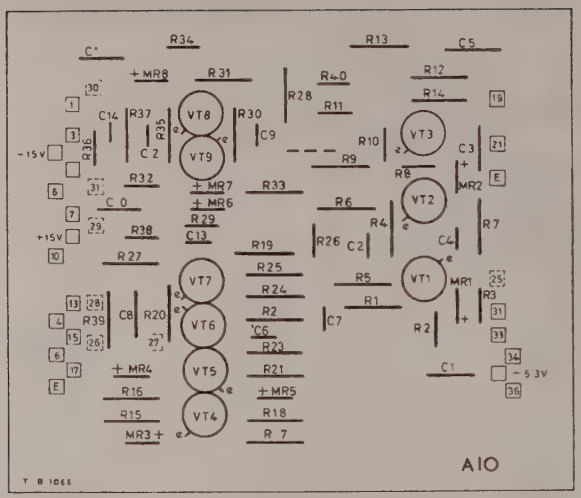
Cathode ray tube

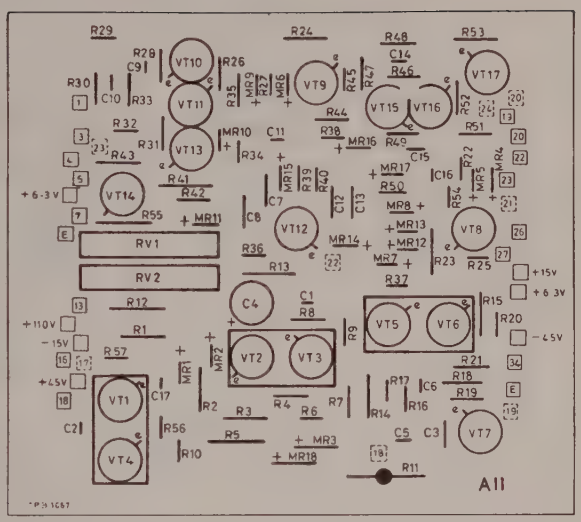
To replace the c.r.t. follow the removal instructions (Sect. 4.3) in reverse order. The c.r.t. is particularly vulnerable to damage and the warnings given in the removal instructions apply equally for replacement.

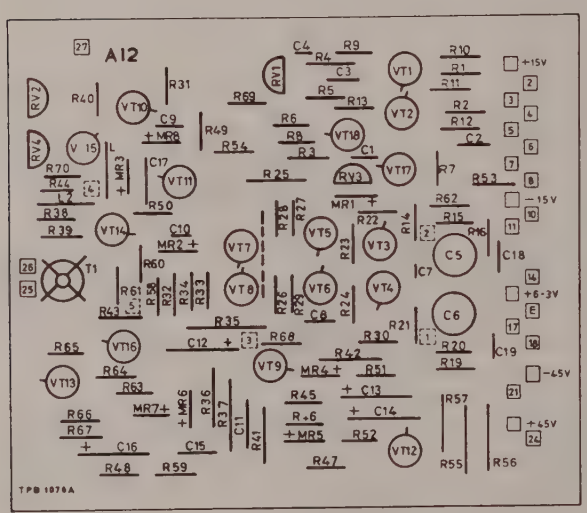


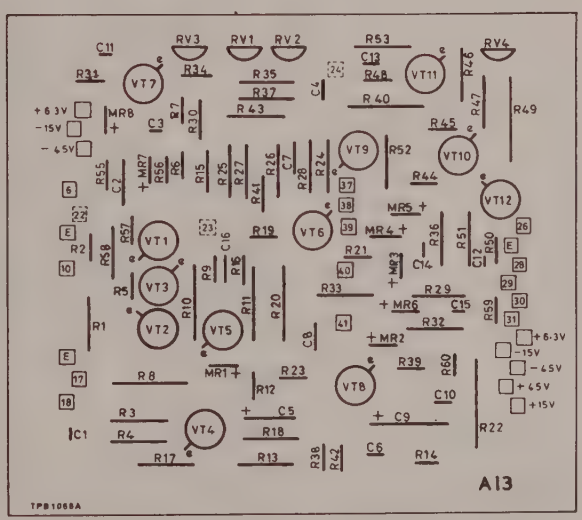
Note: A4 is not illustrated because each component on the board is identified in the legend.

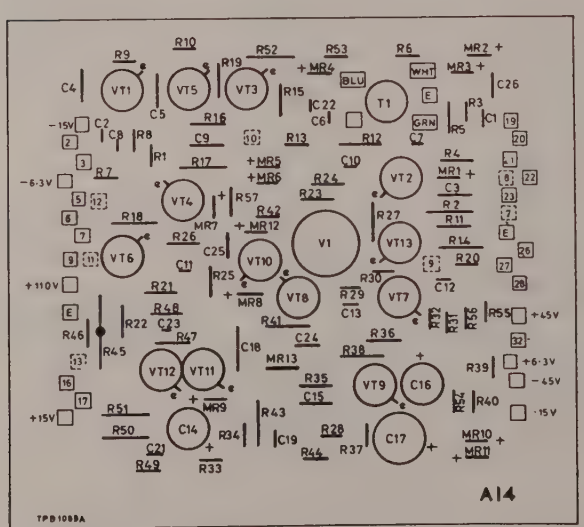


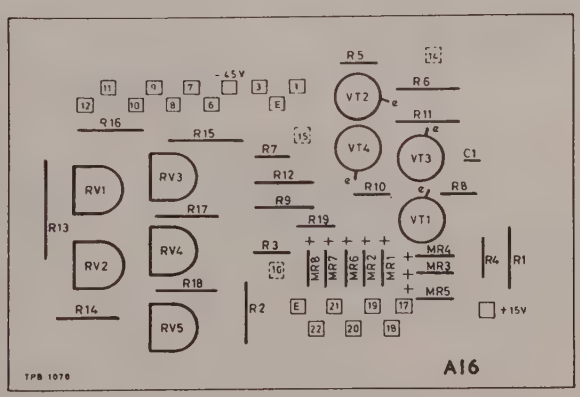

A10

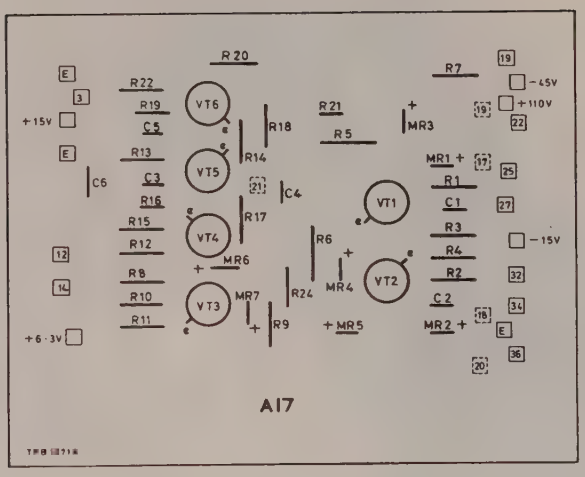

A11

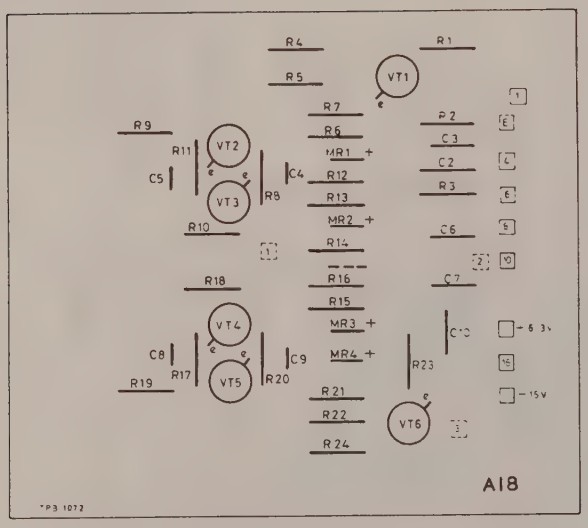

A12

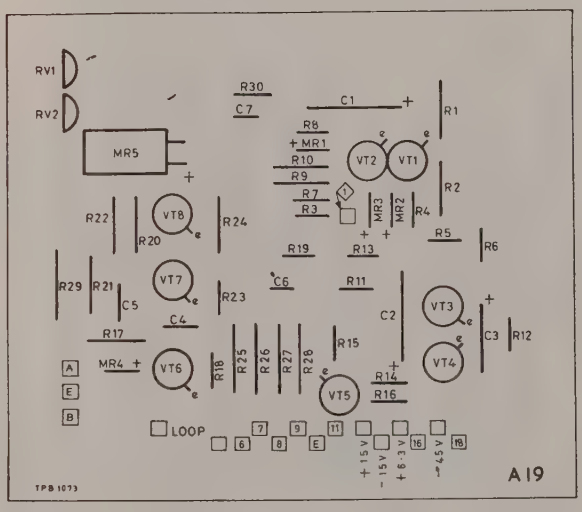

A13


A14


A16

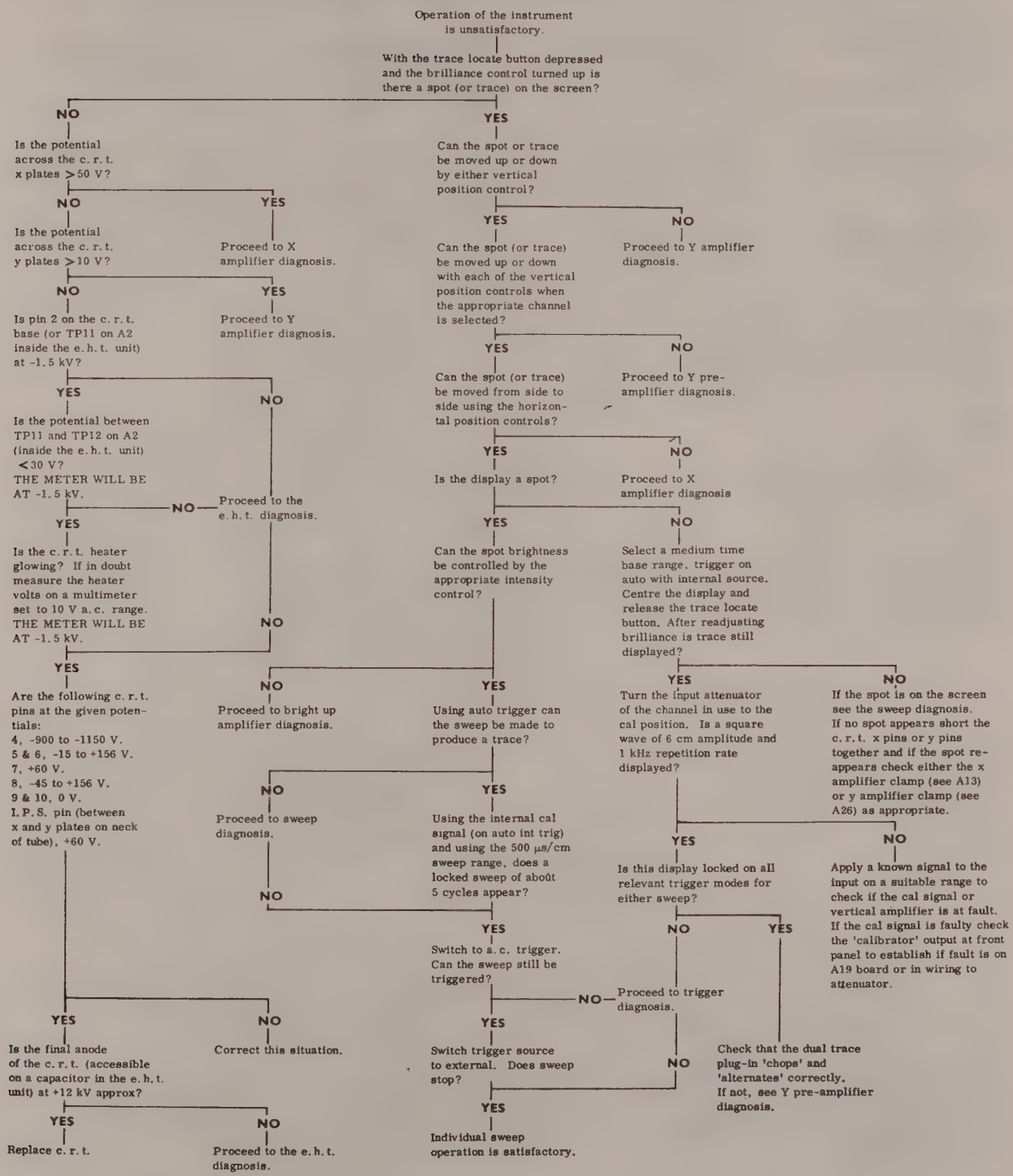

R20
R22
R19
C5
R13
C3
R16
R15
R12
R8
R10
R11
C6
+15V
+6·3V
VT6
VT5
VT4
VT3
MR6
MR7
R18
R14
R17
R9
R21
R5
MR3
R7
-45V
+110V
MR1 +
R1
C1
VT1
R3
R4
R2
C2
MR2 +
R6
R24
MR4
VT2
+MR5
-15V
A17


R4
R1
R5
VT1
R7
R6
MR1 +
R12
R13
MR2 +
R14
R16
R15
MR3 +
MR4 +
R21
R22
R24
R9
R11
VT2
VT3
C5
C4
R8
R10
R18
VT4
VT5
C8
R17
R19
C9
R20
P 2
C3
C2
R3
C6
C7
R23
VT6
- 6 3 V
-15V
A18


RV1
RV2
MR5
R30
C7
C1
R1
R6
+MR1
R10
R9
R7
R3
VT2
VT1
MR3
MR2
R4
R2
R22
VT8
R20
R24
R19
R13
R5
R6
R29
R21
VT7
C5
R23
C6
R11
C2
VT3
C3
R12
R17
C4
MR4 +
VT6
R18
R25
R26
R27
R28
R15
R14
VT4
VT5
R16
LOOP
+15V
-15V
+6·3V
-45V
A19

5.4 FAULT FINDING

GENERAL DIAGNOSIS


Operation of the instrument is unsatisfactory.
With the trace locate button depressed and the brilliance control turned up is there a spot (or trace) on the screen?
NO
YES
Is the potential across the c. r. t. x plates >50 V?
NO
YES
Is the potential across the c. r. t. y plates >10 V?
NO
YES
Is pin 2 on the c. r. t. base (or TP11 on A2 inside the e. h. t. unit) at -1.5 kV?
YES
NO
Is the potential between TP11 and TP12 on A2 (inside the e. h. t. unit) <30 V? THE METER WILL BE AT -1.5 kV.
NO
YES
Is the c. r. t. heater glowing? If in doubt measure the heater volts on a multimeter set to 10 V a. c. range. THE METER WILL BE AT -1.5 kV.
NO
YES
Are the following c. r. t. pins at the given potentials: 4, -900 to -1150 V. 5 & 6, -15 to +156 V. 7, +60 V. 8, -45 to +156 V. 9 & 10, 0 V. I. P. S. pin (between x and y plates on neck of tube), +60 V.
YES
NO
Is the final anode of the c. r. t. (accessible on a capacitor in the e. h. t. unit) at +12 kV approx?
YES
NO
Replace c. r. t.
Proceed to the e. h. t. diagnosis.
Proceed to X amplifier diagnosis.
Proceed to Y amplifier diagnosis.
Proceed to the e. h. t. diagnosis.
Proceed to bright up amplifier diagnosis.
Proceed to sweep diagnosis.
Correct this situation.
Proceed to the e. h. t. diagnosis.
YES
NO
Can the spot or trace be moved up or down by either vertical position control?
YES
NO
Can the spot (or trace) be moved up or down with each of the vertical position controls when the appropriate channel is selected?
Proceed to Y amplifier diagnosis.
YES
NO
Can the spot (or trace) be moved from side to side using the horizontal position controls?
Proceed to Y pre-amplifier diagnosis.
YES
NO
Is the display a spot?
Proceed to X amplifier diagnosis
YES
NO
Can the spot brightness be controlled by the appropriate intensity control?
Select a medium time base range, trigger on auto with internal source. Centre the display and release the trace locate button. After readjusting brilliance is trace still displayed?
YES
NO
Using auto trigger can the sweep be made to produce a trace?
YES
NO
Using the internal cal signal (on auto int trig) and using the 500 μs/cm sweep range, does a locked sweep of about 5 cycles appear?
YES
NO
Switch to a. c. trigger. Can the sweep still be triggered?
YES
NO
Switch trigger source to external. Does sweep stop?
YES
NO
Individual sweep operation is satisfactory.
Proceed to trigger diagnosis.
YES
NO
Turn the input attenuator of the channel in use to the cal position. Is a square wave of 6 cm amplitude and 1 kHz repetition rate displayed?
YES
NO
Is this display locked on all relevant trigger modes for either sweep?
YES
NO
Check that the dual trace plug-in 'chops' and 'alternates' correctly. If not, see Y pre-amplifier diagnosis.
Apply a known signal to the input on a suitable range to check if the cal signal or vertical amplifier is at fault. If the cal signal is faulty check the 'calibrator' output at front panel to establish if fault is on A19 board or in wiring to attenuator.
YES
NO
If the spot is on the screen see the sweep diagnosis. If no spot appears short the c. r. t. x pins or y pins together and if the spot re-appears check either the x amplifier clamp (see A13) or y amplifier clamp (see A26) as appropriate.

Y PRE-AMPLIFIER DIAGNOSIS

Measure the potential at TP1 on A23 (CH 1) or TP7 on A24 (CH 2). Is it +1.5 V (±0.1 V)?

YES

Measure the potential at TP2 on A23 (CH 1) or TP8 on A24 (CH 2). Is it +1.5 V (±0.1 V)?

YES

On x1 gain is the potential on TP's 5 and 6 on A23 (CH 1) or 11 and 12 on A24 (CH 2) about +9.7 V?

YES

On x10 gain, is the potential on TP's 5 and 6 on A23 (CH 1) or 11 and 12 on A24 (CH 2) about +9.7 V?

YES

Measure the potentials on TP's 23 and 24 on A25. Move the DISPLAY switch from ALT through CH 1, SUM, CH 2 and CHOP. Do the potentials take the following values?

Switch position	TP23	TP24
ALT	Alternating at sweep rate between +20.2 V and +12.4 V.	Alternating at sweep rate between +12.4 V and +20.2 V.
CH 1	+12.4 V.	+20.2 V.
SUM	+13 V (±1 V).	+13 V (±1 V).
CH 2	+20.2 V.	+12.4 V.
CHOP	Alternating at 1 MHz between +20.2 V and 12.4 V.	Alternating at 1 MHz between +12.4 V and +20.2 V.

YES

Check the d.c. levels around VT19, VT20 on A25 (CH 1), VT23, VT24 on A25 (CH 2) and compare with values on circuit diagrams. If correct, check the sensitivities of the various test points using an input signal and an oscilloscope.

NO

Check VT5 and VT7 and associated circuitry.

NO

Check potentials around VT1, VT6, VT7 and associated circuitry comparing with those on the circuit diagram.

NO

Check potentials at TP's 3 and 4 on A23 (CH 1), or 9 and 10 on A24 (CH 2) and compare with values on circuit diagram. If in error check around VT2, VT3, VT4 and VT5 for discrepancies in the d.c. levels.

NO

Using circuit A22 check through the potentials on V2 (CH 1) or V3 (CH 2) and find fault.

NO

Using circuit A22 check through potentials on V1 (CH 1) or V4 (CH 2) and find fault.

TRIGGER DIAGNOSIS

Apply a 2 cm p-p signal at 100 kHz on a suitable attenuator range, and select internal trigger on 'Auto' from the channel in use. Using an oscilloscope measure the potentials on TP's 1 and 2 on A12. Has the signal a p-p amplitude of 0.2 V?

YES

Measure the signal amplitude at TP3 on A12. Is the waveform limiting and about 10 V p-p around a mean of +15 V?

YES

Measure the d.c. potential at TP5 on A12. Is this +5 V or less?

YES

Remove the input signal. Does the potential at TP5 on A12 rise to about +19 V?

YES

Reapply the signal. Is the waveform at TP4 on A12 a square wave (with slightly rounded tops) whose amplitude is about 0.4 V p-p around a mean of +14.5 V?

YES

Measure the signal on pin 26 on A12 (situated on edge of board remote from edge connector). Is there a negative-going pulse about 4 V in amplitude and 10 ns in width?

NO

Check VT14 and T1.

YES

The trigger unit must be working correctly. Therefore if the sweep is still not triggering trace the previous pulse (pin 26 on A12) through to pin 23 (TP 7) on A14. If this pulse is present see sweep diagnosis.

NO

Check around VT7, MR2, tunnel diode MR3, VT10, VT11 and VT15. (Circuit diagram d.c. levels are only correct for no signal condition.)

NO

Check why VT13 is not turned on. Compare d.c. levels around VT13, VT16 with those given on the circuit diagram.

NO

Check why the 10 V signal on TP3 is not transmitted via VT9, C12 and rectified via MR6 and MR7 cutting off VT13 and turning on VT16.

NO

Check the sensitivity at the collectors of VT5, VT6 and compare the d.c. levels with those given on the circuit diagrams and thus deduce the fault.

NO

Is the signal at the edge connector pins 4 and 5 22 mV p-p?

YES

Check through the signal paths via VT1 and VT2 and select switches to find where the signal break exists. Compare d.c. levels with those given on circuit diagnosis.

NO

Check back using circuits A7 (A sweep) and A8 (B sweep) and A0, A20 to A25, TP's 21 and 22. If still no signal check back via VT21, VT22 and VT's 9, 10, 15, 16 (CH 1) and VT's 13, 14, 18, 19 (CH 2).

Y AMPLIFIER DIAGNOSIS

Is the potential on TP28 of A25 at +15.5 V?

YES

Are the potentials at TP's 13 and 14 on A25 and TP's 15, 16, 17, 18, 19, 20 on A26 correct? Are the potentials at the collectors of VT's 7 and 8 on A26 and at the collectors of VT's 1 and 2 on A20 correct? If any of these differ significantly from those given on the circuit diagram, the reason must be traced and rectified. If the d.c. levels are correct, the balanced sensitivities at the various test points should be checked using either d.c. shifts method and a voltmeter, or a test signal and oscilloscope. When measuring these potentials with a voltmeter, an r.f. stopping resistor may need to be inserted in the lead to prevent parasitic oscillations.

NO

Is the error large (> 2 V) or small?

small

Is the error in potential at TP's 13 and 14 of opposite sign to that at TP28 (i.e. if TP28 is low then TP's 13 and 14 will be high)?

YES

The fault will be in the circuitry preceding MR35 and MR36. Check whether the fault is in CH 1 or CH 2 or both, by switching the dual trace display switch.

NO

The fault will be in VT27, VT28, VT25, VT26 or the components on A26. Compare d.c. levels with values on circuit diagrams.

large

Check around the other d.c. levels on VT27, VT28 and compare with those on circuit diagram.

BRIGHT-UP MIXER DIAGNOSIS

If trouble with the bright up is experienced, first remove both the A and B sweeps. Is there a spot displayed on the screen?

NO

Connect a 270 Ω resistor between 'Intensity Mod' socket (located on top spine of oscilloscope) and earth. Does a spot appear on the screen?

YES

Replace the A and B sweep units. Turn both the A and A & B intensity controls fully counter-clockwise. With the sweeps not running (i.e. triggers to 'AC', 'Ext'), is there a bright spot on the screen?

NO

Switch the time base display switch to 'Alt' and the trigger switches to 'Auto', 'Ext', leaving both intensity controls fully counter-clockwise. Are either or both sweeps brightly displayed?

NO

Slowly advance the 'A intensity' control clockwise. After about 30° of rotation, does the A sweep trace start to brighten and increase to an unfocussed level as the control is turned fully clockwise?

YES

Return the 'A Intensity' control to its clockwise position and slowly advance the 'A & B Intensity' control. As the control is rotated, does the B trace and then the A trace gradually increase in brightness until both are at full brightness?

YES

Unit is satisfactory.

NO

Switch the triggers from 'Auto' to 'AC' and measure the d.c. levels around VT4 on A10 (A sweep), if the A sweep brightness is at fault, and establish why the collector current of VT4 does not increase as the potential at pin 14 on A10 falls from +6.3 V to earth as the 'A & B Intensity' control is rotated. Measure potentials around VT3 on A17 (B sweep) if the B sweep brightness is at fault, and establish why the collector current of VT3 does not increase as potential at pin 14 on A17 falls from +6.3 V to earth as the 'A & B Intensity' control is rotated.

YES

Check whether only the A sweep or both sweeps are being displayed by use of trace separation control. If A sweep is being displayed, check why the +15 V at pin 16 on A10 (A sweep) and/or the +6.3 V at pin 14 on A10 (A sweep) does not cut off VT4 on A10. If the B sweep is displayed, check why the +6.3 V at pin 14 on A17 (B sweep) does not cut-off VT3 on A17.

NO

Switch the triggers from 'Auto' to 'AC' and measure the d.c. levels around VT4 on A10 (A sweep) and establish why the collector current of VT4 does not increase as the potential at pin 16 on A10 falls from +15 V to earth as the 'A Intensity' control is rotated.

YES

Disconnect the lead from pin 36 on A17 in the B sweep. Does the bright spot remain?

YES

Measure the potential at pin 16 on A10 (A sweep). Is it +15 V?

YES

Check why VT4 is not cut-off and correct the fault.

NO

Trace the wiring back to the slider of the 'A Intensity' potentiometer using circuits A7 and A0.

NO

Measure the potential at pin 14 on A17 (B sweep). Is it +6.3 V?

YES

Check why VT3 is not cut-off and correct the fault.

NO

Trace the wiring back to the slider of the 'A & B Intensity' potentiometer using circuits A8 and A0.

E.H.T. DIAGNOSIS

No e.h.t.

Is there a square wave signal of 0 to +5 V at 18 kHz at TP7 on A2?

YES

Is there a square wave signal of 0 to +30 V at 18 kHz at TP8 on A2?

YES

Is there a positive-going pulse at 18 kHz repetition rate, and about 300 V amplitude on the collector of VT6?

YES

Check which d.c. output is missing and trace to the appropriate rectifier and replace.

NO

Check that the +45 V line is present on all points of the circuit. Check VT6 is receiving base drive via T1 and is not destroyed. If this is so unload the secondary windings of T2 until a correct primary waveform is obtained.

NO

Check VT's 3, 4, 5 and associated components.

NO

Check +15 V line on pin 9 of the edge connector and check the multivibrator VT1, VT2, etc.

SWEEP DIAGNOSIS

It is useful to break the possible faults into three broad groups:

(A) Sweep running (as measured at TP13 on A14) but not being displayed.

(B) Only a d.c. level present at TP13 on A14 when trigger pulses are present on TP7 on A14.

(C) Sweep running, although no trigger pulses are present on TP7 on A14.

STATE (C)

If the sweep is free running, check that the trigger pulses are not present on TP7 on A14. If they are present see the trigger diagnosis. If no trigger pulses are present, measure the instantaneous potentials on VT3 and VT5 with an oscilloscope. Compare the VT3 on, VT5 off state, with the potentials shown on the circuit diagram. Also check that the trace finder is not shorted to earth. Finally, if the trace shortens from the left-hand side of the screen at certain sweep speeds and trigger rates (use 'Auto', 'Ext' for most severe test) suspect malfunction of trigger lock out gate drive circuitry, MR8, VT8, VT7 and waiting capacitors.

STATE (A)

If there is a positive-going saw-tooth of about 20 V in amplitude at TP13 on A14, measure the signal on one of the c.r.t. x pins. Is there a saw-tooth of about 50 V amplitude?

- NO
  - Is there a positive-going saw-tooth of about 20 V amplitude at TP22 on A13 (B sweep)?
    - YES
      - Proceed to X amplifier diagnosis.
    - NO
      - Is the same saw-tooth present on TP19 on A17?
        - YES
          - Check lead between pin 22 on A17 and pin 6 on A13.
        - NO
          - Is the saw-tooth present on TP17 on A17 (if A sweep is being tested) or TP18 on A17 (if B sweep is being tested?
            - YES
              - Check VT1, VT2 and MR's 1 to 4 on A17.
            - NO
              - Check the lead between these pins and pin 13 on A14 using circuits A8, A0 and A7 for the A sweep case.
- YES
  - Does a bright-up waveform between the levels of -1.5 V and 0 V exist at TP11 on A14?
    - YES
      - Proceed to bright up mixer and/or bright up amplifier diagnosis.
    - NO
      - Check VT6 and connections to find fault. Check for broken lead out to pin 36 on A10 (A sweep), pin 12 on A17 (B sweep).

STATE (B)

Is the d.c. potential at TP13 on A14 greater than +30 V?

- YES
  - Measure the potential on TP11 on A14. Is it nearest to 0 V or -1.7 V?
    - -1.7 V
      - Measure the potential on TP10 on A14. Is it positive?
        - NO
          - Check why VT3 or VT10 is conducting. VT3 should be turned off by VT5. VT10 should be turned off by VT9 shutting off as MR9 is reverse biased.
        - YES
          - Check why this potential is not transmitted via MR12 and V1 to cause VT11 to conduct and pull down TP13 to its correct +4.4 V waiting potential.
    - 0 V
      - Find out why the greater than +30 V on TP13 on A14 is not turning on MR7 (via R25) which should turn on VT5 thus making TP11 reside in its low state.
- NO
  - Is the d.c. potential at TP13 on A14 in the range +5 V to +30 V?
    - YES
      - Is the potential at TP10 on A14 positive?
        - NO
          - Measure the potential at TP12 on A14. Is it more negative than the potential at TP10 by a diode's potential drop?
            - NO
              - Check the d.c. levels around the aiming potential board A16. Use circuit A15 to follow the wiring around the range switch.
            - YES
              - Check why this negative level is not transmitted via V1 to cut-off VT11 and thus allow TP13 to rise to its recycling potential. If VT11 is cutting off suspect additional loading from TP13 to ground, in particular suspect load external to the board and check by removing lead out from pin 13 of A14 board.
        - YES
          - Check why this potential is not transmitted via MR12 and V1 to cause VT11 to conduct and pull down TP13 to its correct +4.4 V waiting potential.
    - NO
      - Is the d.c. potential at TP13 on A14 between +4 V and +5 V?
        - YES
          - Deduce why the trigger pulses at TP7 are not transmitted via VT2, T1 and MR4 to the base of VT3 thus lowering the potential at TP10 and turning off VT11 via MR12 and V1.
        - NO
          - If the potential at TP13 on A14 is less than +4 V, check the waiting point amplifier VT9 and VT10, or suspect low resistance to earth from TP13.

FAULTS ON TRIGGERED DELAY (A + B, or B)

Settings as for variable delay

Are there negative-going trigger pulses present at TP7 on A14 (A sweep)?

- NO → Proceed to trigger diagnosis.
- YES → Is there a positive going sweep present on TP13 of A14 (A sweep)?
  - NO → Proceed to sweep diagnosis
  - YES → Is this waveform present on TP17 of A11 (A sweep)?
    - NO → Check wiring using circuit A7.
    - YES → Is there a 5 V square wave at TP18 on A11 (A sweep) whose positive-going transition is adjustable in timing (relative to the start of the A sweep) by rotation of the cm delay potentiometer?
      - NO → Check VT's 1, 2, 3, 4, 5, 6, MR's 1, 2, 3, 18 and assoc. circuitry.
      - YES → Is there a 6 V negative-going pulse on TP19 on A11 (A sweep)?
        - NO → Check VT7 and circuitry.
        - YES → Is this pulse on pin 1 of A10 (A sweep)?
          - NO → Check wiring using circuit A7.
          - YES → Is the potential at TP31 on A10 (A sweep) at +5 V, +1 V or alternating between these two values.
            - Alternating → The delayed sweep must be operating satisfactorily so any faults will probably lie in the sweep and unblanking combining circuits, see bright-up mixer diagnosis.
            - +1 V → Is this potential present on pin 20 of A16 (B sweep)?
              - NO → Check wiring using circuits A7, A0, A8.
              - YES → Does a similar potential (say from +0.5 to +1.5 V) exist at TP14 on A16 (B sweep)?
                - NO → Check potentials on MR's 4, 5, 7, 8 and compare with circuit A16. Rectify accordingly.
                - YES → Is this same potential present on TP8 on A14 (B sweep)?
                  - NO → Check connection.
                  - YES → Are negative-going pulses about 4 V in amplitude and 10 ns wide present at TP7 on A14 (B sweep)?
                    - NO → Proceed to trigger diagnosis.
                    - YES → Are positive-going pulses about 5 V in amplitude present at the collector of VT2 on A14 (B sweep)?
                      - YES → Proceed to sweep diagnosis.
                      - NO → Check VT2 on A14 and circuitry.
            - +5 V → Find out why the negative-going pulse presented to MR8 is not cutting off VT8 and turning on VT9.

X AMPLIFIER DIAGNOSIS

Set both sets of trigger controls as follows:

Mode - A.C.
Source - Ext.
Level - Fully clockwise.

Is the potential at TP22 on A13, +4.7 V (±0.5 V)?

- NO → Check back to pin 22 on A17 (TP19) and thence back via TP17 and TP18 on A17 to TP13 on A14 in the appropriate sweep unit. If still incorrect see sweep diagnosis.
- YES → Can the potential at TP23 on A13 be varied from +11 V to +18 V by means of the horizontal position controls?
  - NO → Check potentials across the horizontal position controls and d.c. levels around VT's 2, 3, and 4.
  - YES → Can the potential at TP24 on A13 be varied from -5 V to +1 V by means of the horizontal position controls?
    - NO → Check the d.c. levels around VT's 6-9 and MR's 2-5.
    - YES → Can the collector potentials of VT10 and VT12 on A13 both be moved by about 1 V around a mean of +4.5 V by means of the horizontal position controls?
      - NO → Check the d.c. levels around VT10, VT11 and VT12, also check the emitter ends of R6 and R7 on A0 are at +5.6 V.
      - YES → Can the potential on the c.r.t. x plate pins be varied between +35 V to +85 V? (Collectors of VT3 and VT4 on circuit A0).
        - NO → Check that the +110 V line is at the correct potential and check VT3, VT4.
        - YES → C.r.t. must be at fault.

BRIGHT-UP AMPLIFIER DIAGNOSIS

With the intensity controls turned to mid-travel and the B sweep running at 1 ms/cm (establish, if not visible on the screen, by measuring gate out waveform), is there a bright-up pulse on TP2 on A1, of about 0.5 V amplitude?

- NO → See the bright-up mixer diagnosis.
- YES → Is there a 5 to 10 V bright-up signal at the emitter of VT2 on A1?
  - NO → Check VT1, VT2, MR1 etc.
  - YES → Is there a 30 to 50 V bright-up signal on TP3 on A1?
    - NO → Check VT3 etc.
    - YES → Is the same (though smaller) signal modulated onto an 18 kHz square wave carrier at TP10 on A2 (in e.h.t. unit)?
      - NO → Check connection through from TP1 on A1 to VT7 on A2. Also check VT7, MR7 etc.
      - YES → Remove the diode MR6 on A2 and earth TP11 on A2. Now check the passage of the signal from the modulator (VT7) via d.c. restorer MR8, MR9 etc., and via combining components R16, C8 to grid of c.r.t. Some pulse tilt is inevitable in these measurements due to the high impedance of the circuit under test. Use at least a 10 MΩ probe.

FAULTS ON VARIABLE DELAY (A + B, or B)

Settings:

10 µs/cm on A sweep, 1 µs/cm on B sweep, cm delay pot. to 5.00, triggers to 'Int', 'Auto'. Apply a 100 kHz test signal and suitably adjust other controls.

Is there a negative-going trigger pulse on TP7 of A14 (A sweep)?

- NO: Proceed to trigger diagnosis.
- YES: Is there a positive-going sweep present on TP13 of A14 (A sweep)?
  - NO: Proceed to sweep diagnosis.
  - YES: Is this waveform present on TP17 on A11 (A sweep)?
    - NO: Check wiring using circuit A7.
    - YES: Is there a 5 V square wave at TP18 on A11 (A sweep) whose positive-going transition is adjustable in timing (relative to the start of A sweep) by rotation of the cm delay control?
      - NO: Check VT's 1, 2, 3, 4, 5, 6 and MR's 1, 2, 3, 18 and associated circuitry.
      - YES: Is there a 6 V negative-going pulse on TP19 on A11 (A sweep)?
        - NO: Check VT7 and circuitry.
        - YES: Is this pulse on pin 20 of A14 (B sweep)?
          - NO: Check wiring using circuits A7, A10 and A8.
          - YES: Is a sweep being generated at TP13 on A14 (B sweep)?
            - NO: Check at what point the pulse ceases to exist en route from pin 20 on A14 (B sweep). If present at the base of VT3 on A14, see sweep diagnosis.
            - YES: If the sweeps are still not correctly displayed, see bright-up mixer diagnosis.

FAULTS ON NORMAL (ALT)

Setting as for variable delay (A+B) except for delay off and DISPLAY switch to ALT. Again it is assumed that the unit functions correctly on normal (A), normal (B) and variable delay (Alt) positions.

Is potential of TP20 on A11 (A sweep) 0 V to +6 V?

- 0 V: Is pin 19 on A16 (B sweep) at the same potential?
  - NO: Check wiring back to A11 using circuits A7, A0 and A8.
  - YES: Is TP14 on A16 (B sweep) at 0 V approximately?
    - NO: Check potentials at MR's 1 to 8 and compare with circuit diagram.
    - YES: Is the potential on pin 22 of A14 (B sweep) at 0 V approximately?
      - NO: Check wiring using circuit A8.
      - YES: Is the B sweep running? (Check saw-tooth at TP13 on A14).
        - NO: Check why trigger pulses at TP7 on A14 are not transmitted via VT2, T1, MR4 to operate VT3, VT5.
        - YES: Is a 6 V bright-up signal present on pin 22 of A11 (A sweep)?
          - NO: Check wiring back to pin 19 on A17 (B sweep) using circuits A7, A0 and A8.
          - YES: Check why this signal is not changing the state of the bistable VT10, VT11 on A11, via the triggering path of MR4, VT8, MR8, C7 and C8.
- +6 V: Is pin 19 on A16 (A sweep) at about 0 V?
  - NO: Check w ring to A11 using A7, A0 and A8.
  - YES: Is TP14 on A16 (A sweep) at 0 V approximately?
    - NO: Check potentials at MR's 1 to 8 and compare with circuit diagram.
    - YES: Is the potential on pin 22 of A14 (A sweep) at 0 V approximately?
      - NO: Check wiring using circuit A7.
      - YES: Is the A sweep running? (Check saw-tooth at TP13 on A14).
        - NO: Check why trigger pulses at TP7 on A14 are not transmitted via VT2, T1, MR4 to operate VT3, VT5.
        - YES: Is a 6 V bright-up signal present on pin 23 of A11 (A sweep)?
          - NO: Check wiring back to pin 13 on A10 (A sweep) using circuit A7.
          - YES: Check why this signal is not changing the state of bistable VT10, VT11 on A11, via the triggering path of MR5, VT8, MR8, C7 and C8.

FAULTS ON VARIABLE DELAY (ALT)

Settings as for variable delay (A+B)

This procedure assumes that the unit works satisfactorily on variable delay (A+B, B) positions.

Is the A sweep still running? (If not displayed on the screen, check at TP13 on A14 A sweep).

- NO: Check why trigger pulses on TP7 are not transmitted to the base of VT3 on A14 (A sweep).
- YES: Is there a square wave between the levels of 0 and +6 V at a repetition rate of half the A sweep rate at TP20 on A11 (A sweep)?
  - NO: Check why the back edge of the bright-up pulse of the A sweep (A2) which enters A11 (A sweep) on pin 23 does not cause the switching bistable to divide by two.
  - YES: Is this waveform present on pin 32 of A17 (B sweep)?
    - NO: Check the wiring between pin 19 on A11 (A sweep) and pin 32 on A17 (B sweep) using circuits A7, A0, A8.
    - YES: Is the equivalent antiphase waveform present on pin 27 of A17 (B sweep)?
      - NO: Check the wiring between pin 5 on A11 (A sweep) and pin 27 on A17 (B sweep) using circuits A7, A0 and A8.
      - YES: Are the two sweep waveforms present at TP17 and TP18 respectively on A17 (B sweep), being presented alternately at TP19 on the same board.
        - NO: Check MR's 1 to 4, and VT's 1 and 2.
        - YES: Proceed to bright-up mixer diagnosis.

5.5 REALIGNMENT

Test equipment required:

a. Heavy duty variac.
b. Multimeter such as Avo model 8.
c. Differential Voltmeter TF 2606.
d. In-situ Bridge TF 2701 (calibrated at 500 Ω).
e. Electronic Voltmeter TF 2604.
f. D.C. Multiplier TM 5033A.
g. 9 V battery.
h. Time marker generator Tektronix 184 or Bradley calibrator 156.
i. Wide Band R-C Oscillator TF 1370A.
j. Pulse generator Tektronix type 109.

5.5.1 Main frame and power supply

Line volts indicator

Test equipment: a, b.

(a) Ensure that the voltage selection panel on the oscilloscope is set to 240 V. Connect the instrument to the supply via the variac. Monitor the supply to the oscilloscope with the multimeter and adjust the variac so that exactly 240 V is applied.

(b) Set the mains supply to 264 V (240 V +10%) and adjust RV1 so that the supply light flashes approximately three times a second. Decrease the mains supply until the light starts to flash slowly. Note this voltage.

(c) If the above voltage is 216 V (240 V -10%) no further adjustment is necessary. If it is a different voltage, readjust RV1 to centre the range.

C.R.T. preset controls

(a) Set the A sweep DISPLAY switch to B, the DELAY switch to OFF and the SWEEP switch to NORMAL. Set the B sweep TIME/CM switch to 0.2 ms/cm.

(b) Adjust the trace rotate control and the channel 1 VERTICAL POSITION control until the trace is parallel to the horizontal centre line on the graticule.

(c) Reset the B sweep TIME/CM control to 1.ms/cm and set the channel 1 VOLTS/CM switch to CAL. Adjust the orthogonality control until the leading and trailing edges of the cal signal are vertical.

(d) Set the centring control to mid-position and check that no part of the display on the screen is cut off, by moving the display to the upper and lower edges of the screen. If it is, adjust the centring control as necessary to eliminate the effect.

(e) Reset the B sweep TIME/CM switch to 10 μs/cm and adjust RV1 (A1) for the best geometrical shape, i.e. no pin cushion or barrel distortion, see Fig. 5.1.

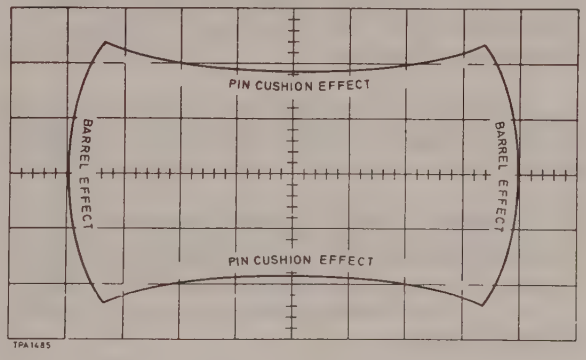


Fig. 5.1 Barrel and pin cushion distortion

Setting—45 V line

Test equipment: a, c.

(a) Connect the oscilloscope to the supply via the variac and ensure that the mains input is 240 V.

(b) Connect the digital voltmeter (set to the 100 V range) between pin 21 on A6 and earth (pin 22). Adjust RV1 on A6 until -45.0 V is indicated on the voltmeter.

(c) Using the voltmeter, check the remaining regulated h.t. lines as follows:

(i) +110 V pin 4 on A6 to earth (pin 7) should be ±1%, i.e. +108.9 V to +111.1 V.

(ii) +45 V pin 17 on A6 to earth (pin 20) should be ±1%, i.e. +44.55 V to +45.45 V.

(iii) +15 V pin 13 on A6 to earth (pin 16) should be ±1%, i.e. +14.85 V to +15.15 V.

(iv) +6.3 V pin 25 on A6 to earth (pin 26) should be ±1%, i.e. +6.24 V to +6.36 V.

(v) -15 V pin 8 on A6 to earth (pin 11) should be ±1%, i.e. -14.85 V to -15.15 V.

(vi) Check the unregulated +156 V line on pin 3 of A6 which should be ±10%, i.e. +140.4 V to 171.6 V.

(vii) Check the unregulated 5.5 V line on pin 12 of A6 which should be ±20%, i.e. -4.4 V to -6.6 V.

E.H.T. check

Test equipment: a, e, f.

(a) Set the variac so that 240 V is applied to the oscilloscope. Connect the TM 5033A d.c. multiplier to the TF 2604 voltmeter and set the range to measure -D.C. Remove the e.h.t. red cover and unhinge A2 board.

(b) Measure the -1.5 kV line on test point 13 of A2 which should be -1.5 kV ±1%, i.e. -1.515 kV to -1.485 kV.

(c) Set the TF 2604 range to measure +D.C. and check the +12 kV at C17 on A2 which should be +12 kV ±10%, i.e. +10.8 kV to +13.2 kV.

Preset brightness

Test equipment: b.

(a) Set the B unit trigger to D.C. and the SOURCE switch on the B sweep unit to EXT so that the B sweep is not triggered. Connect the multimeter, set to the 100 V d.c. range, to test point 3 (A1) and earth (negative to earth). Turn the INTENSITY control fully counter-clockwise and note the voltage on the multimeter (approximately 30 V).

(b) Turn the INTENSITY control clockwise until the voltage previously noted is reduced by 5 V, i.e. from 30 V to approximately 25 V.

(c) Set the B sweep trigger to AUTO and the SOURCE switch to INT. Then with the INTENSITY control set as in (b), adjust RV1 (A2) to produce a trace that has just cut off on the screen. Disconnect the multimeter.

(d) Set the trigger control to AUTO, SLOPE switch to + and SOURCE switch to INT. Set the B sweep TIME/CM switch to 10 ms/cm and adjust RV2 (A2) so that the first centimetre of trace is the same intensity as the remainder of the trace.

(e) Set the B sweep TIME/CM switch to 5 μs/cm and adjust C1 (A1) to even the intensity of the trace over the first few millimetres. Check that the INTENSITY control will vary the trace brilliance from a very bright trace (excessive brilliance) to cut off (no trace at all). Reset B sweep TIME/CM switch to 1 ms/cm.

NOTE: The cut-off point should be at approximately 30% of the total control travel from the fully counter-clockwise position.

(f) Reset the A sweep DISPLAY switch to ALT and the A sweep TIME/CM switch to 1 ms/cm.

(g) Turn the TRACE SEPARATION control to space the two sweeps about 3 cm apart. Adjust the FOCUS, ASTIG and INTENSITY controls to produce clear and sharply focused traces. Adjust the INTENSITY controls in turn and note that the intensity of the A sweep may be varied independently from the B sweep. Reset the two sweeps to the same intensity.

5.5.2 B sweep unit

Horizontal amplifier

Test equipment: c, g, h.

NOTE: Before realigning either sweep unit this check should be carried out.

(a) Connect up the battery and the voltmeter as shown.

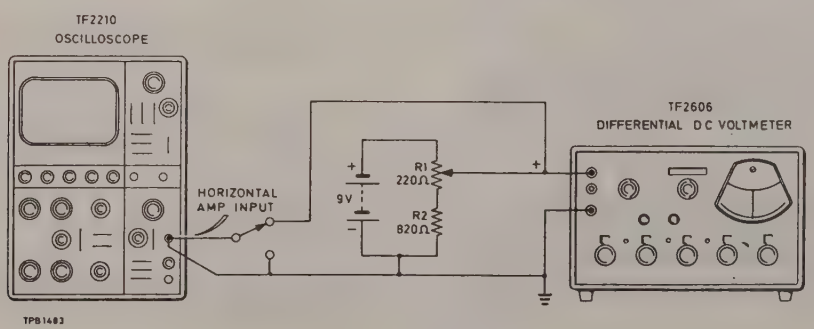


Fig. 5.2 Set up for adjusting the horizontal deflection

(b) Adjust R1 until exactly 8.0 V is applied to the INPUT socket as monitored on the voltmeter, then disconnect.

(c) Set the horizontal amplifier MAG switch to x1. Obtain a trace on the screen derived from the B sweep triggering on AUTO and position the start of the trace on the first vertical graticule line. Switch to D.C. and set the LEVEL control to one end of its travel to stop B sweep being triggered. Increase intensity until a spot appears at the left-hand side of the screen. Short the horizontal amplifier INPUT socket to earth and, with the POSITION controls, move the spot to the 1 cm vertical graticule line (i.e. second line in from the left).

(d) Remove the short circuit and apply the 8 V obtained in (b). The spot should move horizontally to the ninth vertical graticule line - a total of 8 cm.

(e) Adjust RV4 on A13 to obtain a shift of 8 cm, repeat check as necessary.

(f) Switch B sweep trigger to AUTO. Obtain a trace on the screen with the B sweep TIME/CM switch at 1 ms/cm. Connect the time marker generator, set to provide 1 ms x1 marker pulses, to the vertical amplifier INPUT socket. Set the MAG switch to x1 and note that ten marker pulses appear on the screen 1 cm apart.

(g) Set the time marker generator to x5 and the horizontal amplifier MAG switch to x5. Adjust RV1 on A13 until the second and tenth markers coincide with the 1 and 9 cm graticule lines.

(h) Set the time marker generator to 100 μs x1 and the horizontal MAG switch to x10. Repeat the above adjustment using RV2 on A13.

(i) Set the MAG switch to x1 and the marker generator to 1 ms x1. Set the first marker pulse so that it coincides with the fifth centimetre or central graticule line. Switch the MAG switch to x5 and x10 and check that the marker remains central on the screen. If not adjust RV3 on A13 to balance. (Procedure: On x10 centre marker with HORIZONTAL SHIFTS, switch to x1 and re-centre with RV3. Repeat until balance is satisfactory.)

5.5.3 Time range alignment

Test equipment: h.

(a) Set the controls as follows:

Dual trace unit

VOLTS/CM switches to 0.5 V/cm.
VARIABLE VOLTS/CM controls to CAL.
GND-DC-AC switches to DC.
DISPLAY switch to CH1.
TRIGGER switch to CH1.
GAIN switches to x1.
VERTICAL POSITION controls central.
POLARITY switches to NORMAL.

A sweep unit

TIME/CM switch to 100 ms/cm.
VARIABLE TIME/CM control to CAL.
DISPLAY switch to B.
DELAY switch to OFF.
SWEEP switch to NORMAL.
CM DELAY control to zero (fully counter-clockwise).
Trigger switches to DC, +ve, INT.
LEVEL control fully counter-clockwise.

B sweep unit

TIME/CM switch to 0.1 s/cm.
VARIABLE TIME/CM control to CAL.
POSITION controls central.
MAG switch to x1.
Trigger switches to AUTO, +, INT.
LEVEL control fully counter-clockwise.
LENGTH preset control for 10.2 cm of trace.

NOTE: Whilst carrying out this procedure it is advised to calibrate between the 1 cm and 9 cm graticule lines.

(b) Connect the marker generator to the channel 1 input socket on the dual trace unit. Set the generator to provide 100 ms/cm marker pulses. Pulses similar to those shown in Fig. 5.3 should be observed.

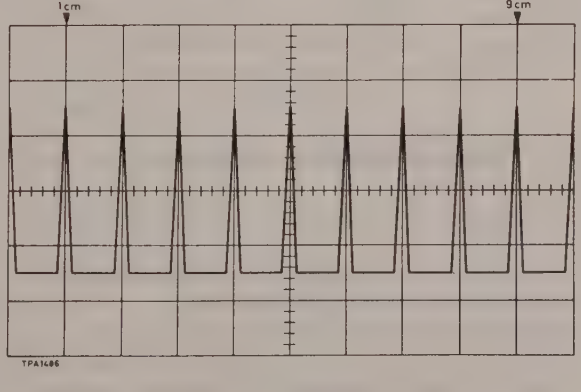


Fig. 5.3 Marker pulses

(c) Adjust RV1 on A16 until the second and tenth marker pulses coincide with the 1 cm and 9 cm graticule lines. Check the 1 s/cm, 0.5 s/cm, 0.2 s/cm, 50 ms/cm and 20 ms/cm ranges for accuracy, they should be within ±2½%, i.e. with the second pulse set on the 1 cm line, the tenth pulse should be within ±2 mm of the 9 cm line.

(d) Continue to set the remaining time ranges the same way. A list of preset controls and the appropriate range for the time marker generator is given below.

Table 5.1

Time/cm range	Marker generator	Preset adjustment
1 s/cm	1 s	
0.5 s/cm	0.5 s	RV1 on A16, set
0.2 s/cm	0.1 s	up on 0.1 s/cm
0.1 s/cm	0.1 s	range
50 ms/cm	50 ms	
20 ms/cm	10 ms*	
10 ms/cm	10 ms	RV2 on A16, set
5 ms/cm	5 ms	up on 5 ms/cm
2 ms/cm	1 ms*	range
1 ms/cm	1 ms	RV3 on A16, set
0.5 ms/cm	0.5 ms	up on 0.5 ms/cm
0.2 ms/cm	0.1 ms*	range
0.1 ms/cm	0.1 ms	RV4 on A16, set
50 µs/cm	50 µs	up on 50 µs/cm
20 µs/cm	10 µs *	range
10 µs/cm	10 µs	RV5 on A16, set
5 µs/cm	5 µs	up on 5 µs/cm
2 µs/cm	1 µs *	range
1 µs/cm	1 µs	C7 mounted on the sweep range switch, set up on 1 µs/cm range
0.5 µs/cm	0.5 µs	
0.2 µs/cm	0.1 µs	
0.1 µs/cm	0.1 µs	
0.05 µs/cm	50 ns	

* Two pulses per division

5.5.4 Trigger alignment

Test equipment: i.

Remove the A sweep unit and connect it to the main frame via an extension lead.

AUTO

(a) Set the oscilloscope controls as follows:

A sweep unit

TIME/CM switch to 10 µs/cm.
VARIABLE TIME/CM control to CAL.
DISPLAY switch to A+B.
DELAY switch to OFF.
SWEEP switch to NORMAL.
Trigger switches to Auto, +ve, Int.

Dual trace unit (Ch 1 only)

VOLTS/CM switch to 5 V/cm.
x1 - x10 gain switch to x10.

(b) Set the TF 1370A as follows:

RANGE switch to D (10 kHz - 100 kHz).
FREQUENCY dial set to 100 kHz.
ATTENUATION IMPEDANCE switch to 75 Ω.
OUTPUT VOLTS SELECTOR switch to 3 V ATTEN (SINE RMS).
ATTENUATED OUTPUT switch to 1 V 0 dB.
SET OUTPUT control set for f.s.d. on the meter.

(c) Set RV4 (on board A12) to its fully counter-clockwise position, viewed from rear of A sweep unit. Connect the output of the TF 1370A to the Ch 1 input and adjust the output to produce a 1.25 cm display. Now switch the x1 - x10 gain switch to x1. Connect a shorting link (i.e. lead with a crocodile clip at each end) between pin 9 (-15 V line) and pin 21 on board A12. Set the A sweep trigger level control to its mid-position and adjust RV2 (on board A12) for a steady triggered display on both positive and negative settings of the SLOPE switch. Now adjust RV4 until the display is only just triggering on both the positive and negative settings of the SLOPE switch.

AC, DC, INT

(a) Set the B sweep trigger switch to AC. Adjust the trigger LEVEL control until the triggering point of the displayed signal is exactly on the centre graticule (horizontal) line.

(b) Set the trigger switch to DC. Adjust RV1 on board A12 until the signal is triggered at exactly the same point as set in (a).

AC, DC, EXT

(a) Set the B sweep trigger switch to AC and the SOURCE switch to EXT.

(b) Connect the test equipment as shown in Fig. 5.4.

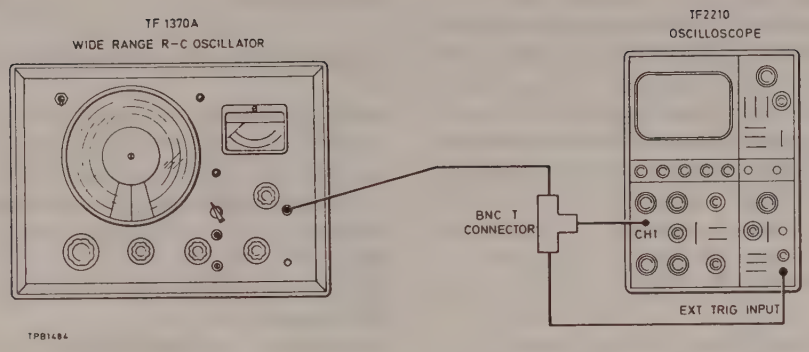


Fig. 5.4 Set up for adjusting the triggering

(c) Adjust the trigger LEVEL control until the triggering point of the displayed signal is exactly on the centre graticule (horizontal) line.

(b) Set the trigger switch to DC and adjust RV3 on board A12 until the signal is triggered at exactly the same point as set in (c).

5.5.5 A sweep unit

The time range and trigger alignment procedures are as described in Sect. 5.6.3 and 5.6.4 for the B sweep unit, the preset controls and the printed circuit boards are identical.

Delay pick-off

Test equipment: h.

(a) Set the controls of the oscilloscope as detailed in Sect. 5.6.3 (d).

Re-position the following controls:

B sweep unit

TIME/CM switch to 50 μs/cm.

A sweep unit

DISPLAY switch to A + B.
DELAY switch to VAR.
Trigger switch to AUTO.

Marker generator

Set for 1 ms pulses.

(b) Set the CM DELAY control fully counter-clockwise to zero. Connect the marker generator to the channel 1 input socket. A trace should be displayed with marker pulses every 1 cm.

(c) Advance the CM DELAY control for 1 cm of delay and adjust RV1 on A11 board so that the bright portion of the trace (the B sweep) starts at the second marker as shown in Fig. 5.5.

(d) Reset the CM DELAY control for 9 cm of delay and adjust RV2 on A11 board so that the bright portion of the trace (the B sweep) starts at the tenth marker pulse, also shown in Fig. 5.5.

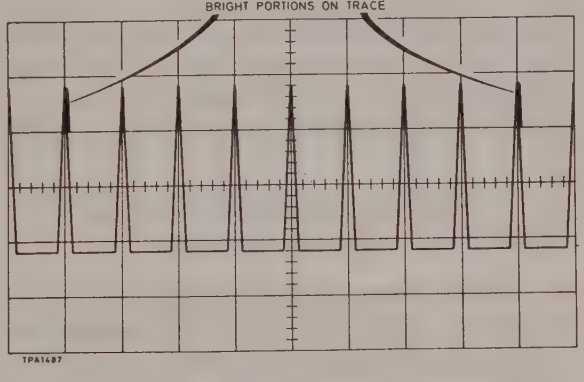


Fig. 5.5 Marker pulses displayed for adjusting the time delay operation

(e) Repeat the above checks for 1 cm and 9 cm delay to minimize errors due to potentiometer interaction.

5.5.6 Adjustments for tube replacement

Vertical sensitivity adjustment

Test equipment: b.

This procedure deals with board A3 which is mounted on the side of the c.r.t. shield. The vertical sensitivity of individual tubes can vary from 2.3 to 3.5 V/cm and the resistive chains RV1, R8 and RV2, R9 shunt the 560 Ω output load

to allow the current sensitivity to be set to a standard value. During manufacture a current source is used to set as many units as possible to a common sensitivity of 5.8 mA/cm, corresponding to 3.25 V/cm across an unshunted 560 Ω load. Those tubes that cannot be so set are compensated for by varying the gain of the vertical amplifier as follows:

(a) Short together pins 12 and 13 on A3 board and turn RV1 fully counter-clockwise.

(b) Remove the lead from pin 10 and connect the multimeter, set to the 100 mA d.c. range, between the pin (positive) and the free end of the lead.

NOTE: Do not bend the lead unnecessarily since its capacitance to chassis will affect the subsequent pulse performance.

(c) Switch on and adjust the front panel controls to obtain an undeflected horizontal trace. Centre the trace with the POSITION controls and note the reading on the multimeter. Rotate the VERTICAL POSITION control until the meter reading increases by 17 mA.

(d) The shunt resistance should now be increased until the trace coincides with the lowest graticule line. Adjust RV1 through its range. If this range is insufficient, remove the connection between pins 12 and 13 and link together pins 14 and 15. Adjust RV2.

(e) If the required adjustment is still not obtained, remove the link altogether.

(f) Remove the multimeter, reconnect the lead onto pin 10. Display the internal cal signal on the screen and adjust RV4 on A26 board for a 6 cm display.

Vertical output delay line adjustment

Test equipment: j.

(a) Set the controls as follows and connect the pulse generator to the channel 1 input.

A sweep unit:

DISPLAY switch to A+B.
DELAY switch to OFF.
Sweep switch to NORMAL.
Trigger switches to AUTO, +ve, INT.
TIME/CM switch to 0.05 μs/cm.
VARIABLE TIME/CM control to CAL.

B sweep unit:

Horizontal amplifier MAG switch to x5.

Dual trace unit:

Input switch to DC.
VOLTS/CM switches to 0.05 V/cm.
VARIABLE VOLTS/CM controls to CAL.
DISPLAY switch to CH 1.
TRIGGER switch to CH 1.
GAIN switch to x1.
POLARITY switch to NORM.

(b) Inductors L1 to L9 on A3 board form a lumped constant delay line with the plate capacitance of the c.r.t. The cores of these inductors require adjustment to give optimum pulse performance with each individual tube. Before commencing adjustments allow the instrument to warm up for at least 15 minutes.

(c) Set the controls of the pulse generator so that a 5 cm high pulse is displayed in the centre of the screen. Unscrew all the cores of the inductors until at least 5 mm of core is visible.

(d) Note the first 20 ns of pulse top. If wriggles occur up to ±5% in amplitude, slowly adjust the cores of inductors L1 to L7 firstly in numerical order and then by observing the pulse shape for the best result.

(e) The object should be to minimize the wriggles, not necessarily to achieve a flat topped pulse. Any tilt which remains can be removed by slightly resetting one or all of the following controls:

Main amplifier A26 board - C8.
Input amplifiers A23 and A24 - RV1 and C2.

(f) After carrying out the above readjustments it will be necessary to realign each input amplifier so that equal performance is obtained on both channels.

(g) Finally adjust L8, L9 in conjunction with C13 on A26 to give the best rise time consistent with a negligible 'hook' at the top of the leading edge of the pulse.

General note: Avoid screwing the cores in farther than necessary, particularly L8 and L9. It is possible to obtain an excellent pulse shape by adding excessive inductance but the bandwidth will probably decrease.

5.5.7 Calibrator

Test equipment: c, d.

(a) Disconnect the wire on pin 1 of A19. Connect the bridge between the CALIBRATOR loop on the front panel and earth. Measure the resistance which should be 500 Ω ±0.5% (i.e. 497.5 Ω to 502.5 Ω).

(b) Remove the bridge and reconnect the wire.

(c) Set the controls as follows:

A sweep unit

DISPLAY switch to B.
DELAY switch to OFF.
SWEEP switch to NORMAL.
Trigger switched to AUTO.

B sweep unit

TIME/CM switch to 0.2 μs/cm.
VARIABLE TIME/CM control fully clockwise (CAL).
Horizontal POSITION control central.
Horizontal MAG switch to x1.
Trigger switched to AUTO.
SLOPE switch to +.
SOURCE switch to INT.

Dual trace unit

VOLTS/CM switches to CAL.
DISPLAY switch to CHOP.
TRIGGER switch to Ch 1.
VERTICAL POSITION controls central.
POLARITY switches to NORMAL.

Digital voltmeter

Range to 1.0 V.

(d) Connect the voltmeter between the CALIBRATOR loop and earth (negative to earth). Short circuit the base of VT6 on A19 by connecting pins B and E together. Note the voltage indicated on the voltmeter which should be approximately 70 mV.

(e) Switch the voltmeter range to 10 V and disconnect the short circuit on pins B and E. Short circuit pins A and E and adjust RV2 (A19) until the voltage indicated by the voltmeter is 3.0 V plus the voltage previously measured in (d).

e.g. voltage measured in (d) is 70 mV.
voltage to be set up in (e) is 3.070 V.

(f) Monitor the cal waveform on the oscilloscope with the VOLTS/CM switches set to their CAL positions. Check the frequency and mark space ratio as follows: Set the leading edge of the pulse to coincide with the first graticule vertical line, the leading edge of the following pulse (end of the first cycle) should occur on the sixth line ±5.0 mm as shown in Fig. 5.6.

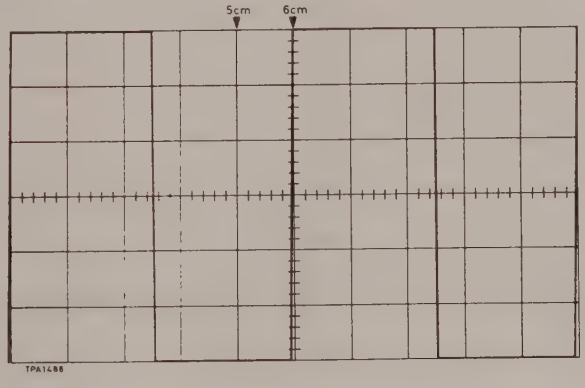


Fig. 5.6 Internal calibration waveform

(g) Adjust the VARIABLE TIME/CM control on the B sweep unit until the end of the first cycle of the cal waveform coincides with the fifth centimetre vertical line. Check that the end of the first pulse occurs on the third centimetre line ±2.0 mm.

Index to Units

Unit number	Description	Parts list page	Circuit diagram Fig.
A0	Main frame	62	7.1
A1	Unblanking circuit and c.r.t	63	7.2
A2	E.H.T. unit	64	7.2
A3	Vertical delay	65	7.1
A4	Rectifier circuits	65	7.3
A5	Power unit	66	7.3
A6	Regulator circuits	66	7.4
A7	A sweep unit interconnection	68	7.5
A8	B sweep unit interconnection	68	7.6
A9	Single sweep unit interconnection	69	7.7
A10	A unit unblanking generator, single shot and triggered delay	69	7.8
A11	Delay pick-off	70	7.9
A12	Trigger circuits	71	7.10
A13	Horizontal amplifier	73	7.11
A14	Sweep circuit	74	7.12
A15	TIME/CM switch circuitry	76	7.10
A16	Trigger gates and aiming potential	76	7.12
A17	B unit unblanking generator, high level sweep gates	77	7.8
A18	Single sweep unit circuitry	77	7.7
A19	Calibrator and supply indicator	78	7.11

A20 to A27 inclusive, see manual EBM 9222

Chapter 6

Replaceable parts

Introduction

Each of the printed boards and other sub-assemblies in the instrument have been allocated a unit identification number in the sequence A0 to A19. The replaceable parts are listed in alpha-numberical order under a main heading of the unit number, unit description and the associated circuit diagram number.

For convenience in the text and on the circuit diagrams, the unit identification is only used where there is a risk of ambiguity.

In the replaceable parts list the following abbreviations are used:-

C : capacitor
Carb : carbon
Cer : ceramic
Elec : electrolytic
ILP : indicator lamp
L : inductor
Met : metal
MR : semiconductor diode
Ox : oxide
PL : plug
Plas : plastic
R : resistor
RV : variable resistor
S : switch
SK : socket
T : transformer
V : valve
Var : variable
Vm : volts maintained
Vs : volts striking
VT : transistor
W : watts at 70 °C
W* : watts at 55 °C
W** : watts at 40 °C
WW : wirewound
X : ferrite bead

Ordering

When ordering replacement parts, address the order to our Service Division (for address see rear cover) or nearest Agent. Specify the following information for each part required:

1. Type and serial number of instrument.
2. Complete circuit reference and unit number.
3. Description.
4. M.I. code number.

If a part is not listed, state its function, location and description when ordering.

A0 Main frame (Fig. 7.1)

Circuit reference	*Description*	*M.I. code*
C2	Cer 0.01μF +80-20% 100V	26383-055
C3	Cer 0.01μF +80-20% 300V	26383-392
C5	Cer 0.01μF +80-20% 100V	26383-055
C6	Cer 0.01μF +80-20% 100V	26383-055
ILP1	6.5V 150mA green	23746-702
ILP2	6.5V 150mA	23735-442
ILP3	6.5V 150mA	23735-442
ILP4	6.5V 150mA	23735-442
ILP5	6.5V 150mA	23735-442
JK1	Projector output	23421-685
L1	Inductor	44254-205
MR1	Lucas DD2020	28355-183
PLAA	6 pin	23423-301
PLE	36 way	23435-412
PLM	24 way	23435-609
PLN	24 way	23435-609
PLS	24 way	23435-609
PLT	24 way	23435-609
PLV	32 way	23435-614
R1	Carb 10Ω 10% ½W	24342-020
R2	WW 2kΩ 1% 4.5W	25114-551
R3	WW 2kΩ 1% 4.5W	25114-551
R4	Carb 10Ω 10% ¼W	24341-220
R5	Carb 10Ω 10% ¼W	24341-220
R6	Carb 39Ω 10% ¼W	24341-235
R7	Carb 39Ω 10% ¼W	24341-235

Circuit reference	Description	M.I. code
RV1	Carb 100Ω 10%	44371-019
RV2	Carb 5MΩ 20% ¼W	44372-501
RV3	Carb a) 1kΩ 20% ¼W b) 1kΩ	44371-232
RV4	Carb 200kΩ 20% ¼W	44372-402
RV5	Carb a) 22kΩ 20% 3/4W b) 22kΩ	44371-239
RV6	WW 250Ω 10% 1W	25815-146
RV7	WW a) 250Ω b) 250Ω	25872-251
RV8	WW 2.5kΩ 10% 1W	25815-117
SA	TRACE FINDER button	44333-410
SB	POWER ON switch	23462-258
SKTAA	6 pin	23424-301
SKTF	50Ω Coaxial	23445-215
SKTG	50Ω Coaxial	23445-215
SKTX	12 way	23435-051
SKTZ	2mm red	23421-126
SKTZE	2mm black	23421-127
TH1	ST & C KS 2Y	25683-424
V1	C.R.T. Philips D13-45GH/03	28235-824
VT1	Mullard OC25	28424-807
VT2	High Voltage n-p-n	44522-018
VT3	SFT 187	28458-334
VT4	SFT 187	28458-334
X1	Ferrite bead	23635-833
X2	Ferrite bead	23635-833
X3	Ferrite bead	23635-833
X4	Ferrite bead	23635-833
X5	Ferrite bead	23635-833
X6	Ferrite bead	23635-833
X7	Ferrite bead	23635-833
X8	Ferrite bead	23635-833
X9	Ferrite bead	23635-833
X10	Ferrite bead	23635-833
X11	Ferrite bead	23635-833
X12	Ferrite bead	23635-833
X13	Ferrite bead	23635-833
X14	Ferrite bead	23635-833
X15	Ferrite bead	23635-833
X16	Ferrite bead	23635-833
X17	Ferrite bead	23635-833
X18	Ferrite bead	23635-833

A1 Unblanking circuit and c.r.t. (Fig. 7.2)

Circuit reference	Description	M.I. code
C1	Cer 0.001μF +80-20% 500V	26383-242
C2	Plas 100pF 2% 125V	26516-241
C3	Cer 0.01μF +80-20% 100V	26383-055
C4	Cer 0.01μF +80-20% 100V	26383-055
C5	Cer 7-35pF +70-10% 160V	26847-121
C6	Cer 0.01μF +80-20% 100V	26383-055
C7	Cer 0.01μF +80-20% 100V	26383-055
C8	Cer 0.01μF +80-20% 2kV	26383-516
C9	Cer 0.01μF +80-20% 2kV	26383-516
C11	Cer 0.01μF +80-20% 100V	26383-055
C12	Cer 0.0045μF +40-20% 2kV	26383-438
C13	Cer 500pF 20% 4kV	26383-427
MR1	Texas Instruments 1S44	28357-548
MR2	Zener diode	28371-408
MR3	Zener diode	28371-848
MR4	Zener diode	28372-308
MR5	1N916	28336-466
R1	Carb 47Ω 10% ½W	24342-037
R2	Carb 47Ω 10% ½W	24341-237
R3	Carb 47Ω 10% ½W	24341-237
R4	Carb 47Ω 10% ½W	24341-237
R5	Carb 47Ω 10% ½W	24341-237
R6	Met ox 1kΩ 5% ½W	24552-080
R7	Met ox 1kΩ 5% ½W	24552-080
R8	Met ox 1.1kΩ 5% ½W	24552-081
R9	Met ox 47Ω 5% ½W	24552-037
R10	Carb 22Ω 10% ¼W	24341-228

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R11	Met ox 390Ω 7% $\frac{3}{8}$W	24552-065
R12	Met ox 3.3kΩ 5% 2W	24587-238
R13	Met ox 10Ω 5% $\frac{1}{2}$W	24552-020
R14	Met ox 4.7kΩ 5% $\frac{1}{2}$W	24552-100
R15	Met ox 20kΩ 5% $\frac{1}{2}$W	24552-117
R16	Carb 470kΩ 10% $\frac{1}{2}$W	24342-126
R17	Carb 6.2MΩ 1% 3/4W	24177-620
R18	Carb 3.9MΩ 1% 3/4W	24177-390
R19	Met ox 120kΩ 5% $\frac{1}{2}$W	24552-137
R20	Met ox 36kΩ 5% $\frac{1}{2}$W	24552-123
R21	Met ox 150kΩ 5% $\frac{1}{2}$W	24552-139
R22	Carb 330Ω 10% $\frac{1}{2}$W	24341-263
RV1	Carb 200kΩ 20% $\frac{1}{4}$W	25541-249
VT1	Motorola MM1613	28454-776
VT2	General purpose n-p-n	28452-197
VT3	Motorola 2N3634	28438-386

A2 E.H.T. unit (Fig. 7.2)

C1	Mica 0.0012μF 2% 350V	26272-160
C2	Mica 0.0012μF 2% 350V	26272-160
C3	Cer 10pF ±0.25pF 750V	26324-709
C4	Cer 0.01μF +80-20% 300V	26383-055
C5	Elec 25μF +100-20% 35V	26417-143
C6	Plas 0.047μF 10% 400V	26512-216
C7	Paper 0.005μF 10% 250V	26174-141
C8	Elec 250μF +100-20% 70V	26417-169
C9	Mica 0.01μF 1% 350V	26268-103
C10	Cer 47pF 2% 750V	26324-833
C11	Cer 0.01μF +100-0% 2kV	26383-516
C12	Cer 0.01μF +80-20% 500V	26383-392
C13	Cer 0.01μF +100-0% 2kV	26383-516
C14	Cer 0.01μF +100-0% 2kV	26383-516
C15	Plas 0.1μF 10% 200V	26582-208
C16	Cer 0.01μF +100-0% 2kV	26383-516
C17	Cer 500pF 20% 20kV	26393-104
C18	Plas 402pF 2% 500V	26516-394
C19	Cer 33pF 5% 3kV	26324-751
C20	Cer 68pF 2% 750V	26324-868
C21	Cer 68pF 2% 750V	26324-868
C22	Cer 68pF 2% 750V	26324-868
L1	1mH Inductor	23642-905
L2	Inductor	44265-016
L3	1mH Inductor	26342-905
MR1	Silicon diode	28336-676
MR2	Silicon diode	28336-676
MR3	Silicon diode	28336-676
MR4	Silicon diode	28336-676
MR5	Lucas DD2026	28357-023
MR6	E.D.I. RK480A	28338-481
MR7	Silicon diode	28336-676
MR8	BA145	28338-137
MR9	BA145	28338-137
MR10	BA145	28338-137
PL1	Anode cap (and lead)	28238-137
R1	Met ox 1.5kΩ 5% $\frac{1}{2}$W*	24552-084
R2	Met ox 33kΩ 1% $\frac{1}{2}$W*	24512-422
R3	Met ox 33kΩ 1% $\frac{1}{2}$W*	24512-422
R4	Met ox 1.5kΩ 5% $\frac{1}{2}$W*	24552-084
R5	Carb 10kΩ 10% $\frac{1}{2}$W	24342-110
R6	Carb 6.8kΩ 10% $\frac{1}{2}$W	24342-106
R7	Carb 100Ω 10% $\frac{1}{4}$W	24341-250
R8	Carb 1kΩ 10% $\frac{1}{2}$W	24342-080
R9	Carb 68Ω 10% $\frac{1}{2}$W	24342-043
R10	Carb 47Ω 10% $\frac{1}{2}$W	24342-037
R11	WW 3.3Ω 10% 1$\frac{1}{2}$W	25133-008
R12	Carb 2.7MΩ 10% $\frac{1}{2}$W	24342-176
R13	Carb 47kΩ 10% $\frac{1}{2}$W	24342-126
R14	Met ox 330Ω 10% $\frac{1}{2}$W	24581-228
R15	Carb 47kΩ 10% $\frac{1}{2}$W	24342-126
R16	Carb 1MΩ 10% $\frac{1}{2}$W	24342-166
R17	Met ox 47kΩ 5% $\frac{1}{4}$W	24581-280
R18	Carb 9.1kΩ 5% $\frac{1}{2}$W*	24552-109
R19	Carb 470kΩ 10% $\frac{1}{2}$W	24342-152
R20	Met 5MΩ 0.5% 1W	24757-583
R21	Met 5MΩ 0.5% 1W	24757-583
R22	Met 5MΩ 0.5% 1W	24757-583

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R23	Met ox 47kΩ 10% ½W	24581-280
R24	Met 453kΩ 0.5% ½W	24755-751
R25	Met ox 1kΩ 5% ¼W	24581-240
R26	Carb 100kΩ 10% ¼W	24341-335
R27	Carb 330kΩ 10% ¼W	24341-348
R28	Carb 330kΩ 10% ¼W	24341-348
R29	Carb 330kΩ 10% ¼W	24341-348
RV1	Carb 100kΩ 20% ¼W**	25541-247
RV2	Carb 50kΩ 20% ¼W**	25541-244
T1	Transformer	43517-001
T2	Transformer	43564-001
TH1	Thermister 1055S	25685-485
V1	Lucas DT4306	28458-803
V2	Thermionic valve	28152-282
VT1	Silicon n-p-n	28451-728
VT2	Silicon n-p-n	28451-728
VT3	Silicon n-p-n	28455-437
VT4	High voltage n-p-n	44522-018
VT5	Marconi 203-04	28455-824
VT6	Lucas DT4306	28458-803
VT7	Fairchild C407	28458-266
VT8	Motorola MM1614	28455-596
VT9	Motorola MM1614	28455-596

A3 Vertical delay (Fig. 7.1)

Circuit reference	Description	M.I. code
C1	0.01μF +80-20% 100V	26383-055
C2	0.01μF +80-20% 100V	26383-055
L1	Inductor	44222-202
L2	Inductor	44222-202
L3	Inductor	44222-202
L4	Inductor	44222-202
L5	Inductor	44222-202
L6	Inductor	44222-202
L7	Inductor	44222-202
L8	Inductor	44222-202
L9	Inductor	44222-202
R1	Met ox 180Ω 5% 5W	24487-556
R2	Carb 6.8kΩ 1% ¼W	24134-680
R3	Carb 8.2kΩ 1% ¼W	24134-820
R4	Met ox 560Ω 1% 2W	24527-272
R5	Met ox 560Ω 1% 2W	24527-272
R6	Met ox 560Ω 1% 2W	24527-272
R7	Met ox 560Ω 1% 2W	24527-272
R8	Met ox 1.3kΩ 5% 1W	24585-129
R9	Met ox 2.2kΩ 5% 1W	24585-134
R10	Met ox 6.8kΩ 5% ¼W	24581-260
RV1	Carb 1kΩ 10%	25541-371
RV2	Carb 5kΩ 10%	25541-375
VT1	Mullard BC107	28455-437

A4 Rectifier circuits (Fig. 7.3)

Circuit reference	Description	M.I. code
C1	50μF +50-20% 150V	26417-488
FS2	1A Quick-blow	23411-058
MR1	Mullard BYX36-300	28356-527
MR2	Mullard BYX36-300	28356-527
MR3	Mullard BYX36-300	28356-527
MR4	Mullard BYX36-300	28356-527
MR5	Mullard BYX36-300	28356-527
MR6	Mullard BYX36-300	28356-527
MR7	Mullard BYX36-300	28356-527
MR8	Mullard BYX36-300	28356-527
MR9	Mullard BYX36-300	28356-527
MR10	Mullard BYX36-300	28356-527
MR11	Mullard BYX36-300	28356-527
MR12	Mullard BYX36-300	28356-527
MR13	Mullard BYX36-300	28356-527
MR14	Mullard BYX36-300	28356-527
MR15	Mullard BYX36-300	28356-527
MR16	Mullard BYX36-300	28356-527
MR17	Mullard BYX36-300	28356-527
MR18	Mullard BYX36-300	28356-527
MR19	Mullard BYX36-300	28356-527
MR20	Mullard BYX36-300	28356-527
MR21	Mullard BYX36-300	28356-527
MR22	Lucas DD2020	28355-183

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
MR23	Lucas DD2020	28355-183
MR24	Lucas DD2020	28355-183
A5	**Power unit (Fig. 7.3)**	
C2	Elec 500μF +50-20% 200V	26427-109
C3	Elec 500μF +50-20% 200V	26427-109
C4	Elec 1000μF +50-20% 100V	26427-121
C5	Elec 2500μF +50-20% 50V	26427-134
C6	Elec 2500μF +50-20% 50V	26427-134
C7	Elec 5000μF +50-20% 35V	26427-147
C8	Elec 1000μF +50-20% 100V	26427-121
C9	Plas 0.047μF 10% 400V	26582-238
C10	Plas 0.047μF 10% 400V	26582-238
C11	Plas 0.047μF 10% 400V	26582-238
C12	Plas 0.047μF 10% 400V	26582-238
FS1	2A Time-lag or	23411-060
	4A Time-lag for 110V operation	23411-063
R1	Carb 68kΩ 10% ½W	24342-131
R2	Carb 56kΩ 10% ½W	24342-129
R3	Carb 27kΩ 10% ½W	24342-120
R4	Carb 10kΩ 10% ½W	24342-110
R5	Carb 10kΩ 10% ½W	24342-110
R6	Carb 5.6kΩ 10% ½W	24342-103
R7	Carb 1.5kΩ 10% ¼W	24342-284
R8	Carb 1.5kΩ 10% ¼W	24342-284
R9	Carb 100Ω 10% ¼W	24341-250
R10	Carb 100Ω 10% ¼W	24341-250
R11	Met ox 2.2kΩ 10% ½W	24582-560
SKTV	32 way	23435-644
T1	Transformer	43467-012
VT1	RCA 2N3583	28458-477
VT2	Motorola 2N3055	28456-567
VT3	Motorola 2N3055	28456-567
VT4	Motorola 2N3055	28456-567
VT5	Motorola 2N3055	28456-567
VT6	Motorola 2N3055	28456-567
A6	**Regulator circuits (Fig. 7.4)**	
C1	Elec 100μF +100-20% 25V	26417-158
C2	Elec 100μF +100-20% 25V	26417-158
C3	Elec 25μF +100-20% 70V	26417-145
C4	Plas 0.047μF 10% 250V	26582-206
C5	Plas 0.047μF 10% 250V	26582-206
C6	Plas 0.047μF 10% 250V	26582-206
C7	Elec 25μF +100-20% 18V	26417-141
C9	Plas 0.047μF 10% 250V	26582-206
C10	Plas 0.1μF 10% 250V	26582-208
C11	Elec 8μF +50-20% 200V	26417-474
C12	Elec 100μF +100-20% 25V	26417-158
C13	Elec 25μF +100-20% 70V	26417-145
C14	Plas 0.1μF 10% 250V	26582-208
C15	Cer 0.001μF +80-20% 500V	26383-242
C16	Cer 0.001μF +80-20% 500V	26383-242
C17	Cer 0.001μF +80-20% 500V	26383-242
MR1	Mullard BYX36-300	28356-527
MR2	Mullard BYX36-300	28356-527
MR3	Mullard BYX36-300	28356-527
MR4	Mullard BYX36-300	28356-527
MR5	Silicon diode	28371-848
MR6	Mullard BYX36-300	28356-527
MR7	Mullard BZY95-C43	28375-337
MR8	Mullard BYX36-300	28356-527
MR9	Mullard BYX36-300	28356-527
MR10	Mullard BYX36-300	28356-527
MR11	Mullard BYX36-300	28356-527
MR12	Mullard BYX36-300	28356-527
MR13	Zener diode	28371-545
MR14	Mullard BYX36-300	28356-527
R1	Met ox 1.1kΩ 5% ½W	24552-081
R2	Met ox 2.7kΩ 5% ½W	24552-092
R3	Met ox 5.1kΩ 5% ½W	24552-101
R4	Carb 10Ω 10% ½W	24342-020
R5	Carb 10Ω 10% ½W	24342-020
R6	Carb 10Ω 10% ½W	24342-020
R7	Met ox 4.7kΩ 5% ½W	24552-100
R8	Met ox 4.7kΩ 5% ½W	24552-100
R9	Met ox 4.7kΩ 5% ½W	24552-100
R10	Met ox 7.5kΩ 5% ½W	24552-107

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R11	Met ox 5.6kΩ 5% ½W*	24552-103
R12	Met ox 12kΩ 5% ½W*	24552-112
R13	Met 1.35kΩ 0.5% ¼W	24755-483
R14	Met 9.65kΩ 0.5% ½W	24755-709
R15	Met 3.4kΩ 0.5% ¼W	24755-494
R16	Met 10.2kΩ 0.5% ½W	24755-711
R17	Met 10kΩ 0.5% ½W	24755-710
R18	Met 10kΩ 0.5% ½W	24755-710
R19	Carb 150Ω 10% ½W	24342-054
R20	Carb 150Ω 10% ½W	24342-054
R21	Carb 150Ω 10% ¼W	24341-254
R22	Carb 560Ω 10% ¼W	24341-272
R23	Carb 1.5kΩ 10% ½W	24342-084
R24	Carb 15kΩ 10% ½W	24342-114
R25	Carb 15kΩ 10% ½W	24342-114
R26	Carb 1kΩ 10% ½W	24342-080
R27	Carb 2.2kΩ 10% ½W	24342-088
R28	Carb 6.8kΩ 10% ½W	24342-106
R29	WW 0.1Ω 10% 1¼W	25133-032
R30	WW 0.33Ω 10% 1¼W	25133-033
R31	WW 0.5Ω 10% 1¼W	25133-031
R32	Carb 470Ω 10% ¼W	24341-269
R33	Carb 470Ω 10% ¼W	24341-269
R34	Carb 470Ω 10% ¼W	24341-269
R35	Carb 2.7kΩ 10% ½W	24342-092
R36	Carb 1kΩ 10% ½W	24342-080
R37	Carb 39kΩ 10% ½W	24342-124
R38	Carb 330Ω 10% ½W	24342-063
R39	Carb 1kΩ 10% ½W	24342-080
R40	Carb 15kΩ 10% ½W	24342-114
R41	Carb 18kΩ 10% ½W	24342-116
R42	WW 3.3kΩ 5% 1¼W	25123-094
R43	Carb 470Ω 10% ¼W	24341-269
R44	WW 1Ω 10% 1¼W	25133-001
R45	Carb 470Ω 10% ¼W	24341-269
R46	Carb 470Ω 10% ¼W	24341-269
R47	Carb 1kΩ 10% ½W	24342-080
R48	Carb 2.2kΩ 10% ¼W	24341-288
R49	Carb 6.8kΩ 10% ¼W	24341-306
R50	Carb 56kΩ 10% ½W	24342-129
R51	WW 0.5Ω 10% 1¼W	25133-031
R52	WW 1Ω 10% 1¼W	25133-001
R53	Carb 10kΩ 10% ½W	24342-110
R54	Carb 270kΩ 10% ½W	24342-146
R55	Carb 10Ω 10% ½W	24342-020
R56	Carb 1.5kΩ 10% ¼W	24341-284
R57	Carb 1.5kΩ 10% ½W	24342-084
R58	Carb 330Ω 10% ½W	24342-063
R59	Carb 1kΩ 10% ¼W	24341-280
R60	Met 27.1kΩ 0.5% ½W	24755-720
R61	Met 11.1kΩ 0.5% ½W	24755-712
R62	Met 2.71kΩ 0.5% ¼W	24755-492
R63	Met 5.42kΩ 0.5% ¼W	24755-503
R64	Met 634Ω 1% ¼W	24764-601
R65	Met 3.92kΩ 1% ½W	24766-601
R66	Met ox 10kΩ 5% ½W	24552-110
R67	Met ox 9.1kΩ 5% ½W	24552-109
R68	Carb 10Ω 10% ½W	24342-020
R69	Met ox 9.1kΩ 5% ½W	24552-109
R70	Met ox 3kΩ 5% ½W	24552-093
R71	Met ox 7.5kΩ 5% ½W	24552-107
R72	Carb 10Ω 10% ½W	24342-020
R73	Carb 10Ω 10% ½W	24342-020
R74	Met ox 30kΩ 5% ½W	24552-121
R75	Met ox 7.5kΩ 5% ½W	24552-107
R76	Met ox 1.8kΩ 5% ½W	24552-086
R77	Met ox 620Ω 5% ½W	24552-074
R78	Met ox 3.9kΩ 5% ½W	24552-096
R79	Carb 100Ω 10% ¼W	24341-250
R80	Carb 100Ω 10% ¼W	24341-250
R81	Carb 100Ω 10% ¼W	24341-250
R82	Carb 100Ω 10% ¼W	24341-250
R83	Carb 100Ω 10% ¼W	24341-250
R84	Carb 100Ω 10% ¼W	24341-250
RV1	WW 100Ω	25886-191
VT1	Low noise n-p-n	28452-777
VT2	Low noise n-p-n	28452-777
VT3	Mullard BFY51	28455-827
VT4	General purpose n-p-n	28452-787

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
VT5	Low noise n-p-n	28452-777
VT6	Low noise n-p-n	28452-777
VT7	Mullard BC107	28455-437
VT8	General purpose n-p-n	28452-787
VT9	Mullard 2N2483	28455-787
VT10	Mullard 2N2483	28455-787
VT11	R.C.A.40349	28458-367
VT12	General purpose n-p-n	28452-787
VT13	General purpose n-p-n	28452-787
VT14	R.C.A.2N3440	28458-617
VT15	General purpose n-p-n	28452-787
VT16	R.C.A.40349	28458-367
VT17	R.C.A.40349	28458-367
VT18	Mullard BC107	28455-437
VT19	General purpose n-p-n	28452-787
VT20	Low noise n-p-n	28452-777
VT21	Low noise n-p-n	28452-777
VT22	R.C.A.40349	28458-367
VT23	General purpose n-p-n	28452-787
VT24	Low noise n-p-n	28452-777
VT25	Low noise n-p-n	28452-777
VT26	General purpose n-p-n	28452-787
VT27	R.C.A.40349	28458-367

A7 A sweep interconnection (Fig. 7.5)

C1	Paper 0.01μF 10% 200V	26174-145
C2	Plas 0.1μF 20% 630V	26511-174
C3	Cer 0.01μF +80-20% 100V	26383-055
C4	Cer 22pF 0.25% 750V	26324-715
C5	Cer 22pF 0.25% 750V	26324-715
C6	Cer 0.005μF 20% 500V	26367-445
C9	Elec 5μF +100-20% 70V	26417-118
C10	Cer 0.01μF +80-20% 100V	26383-055
ILP1	500μA Vs80 Vm60	44731-402
ILP2	6V 70mA amber	23746-701
R1	Carb 4.7kΩ 10% ¼W	24341-300
R2	Carb 4.7kΩ 10% ¼W	24341-300
R3	Carb 100kΩ 10% ¼W	24341-335
R4	Carb 1MΩ 1% ¼W	24145-601
R5	Carb 4.7kΩ 10% ¼W	24341-300
R6	Carb 100kΩ 10% ½W	24342-135
R9	Carb 100Ω 10% ¼W	24341-250
R10	Carb 100Ω 10% ¼W	24341-250
RV1	Carb 10kΩ 10% ¼W	44371-237
RV2	WW 5kΩ 3% 2W	44371-231
RV3	Carb 12kΩ 5% 2W	44371-229
RV4	Carb a) 10kΩ 20% ¼W b) 1kΩ	44371-233
NOTE.	For details of the TIME/CM switch see SA on Unit A15.	
SA	DISPLAY switch	44322-138
SB	DELAY switch	44322-138
SC	SWEEP switch	44322-138
SD	RESET button	23465-156
SE	AUTO-DC-AC switch	44322-137
SF	SLOPE switch	44321-138
SG	SOURCE switch	44322-136
SKTP	50Ω BNC	23443-443
SKTQ	2mm Black	23421-127
SKTR	2mm Red	23421-126
SKTS	24 way	23435-639
SKTT	24 way	23435-639
X1	Ferrite bead	23635-833

A8 B sweep interconnection (Fig. 7.6)

C2	Plas 0.01μF 20% 630V	26511-174
C3	Cer 0.01μF +80-20% 100V	26383-055
C6	Cer 0.005μF 20% 500V	26367-445
C10	Cer 0.01μF +80-20% 100V	26383-055
ILP1	500μA Vs80 Vm60	44731-402
ILP2	500μA Vs80 Vm60	44731-402
R2	Carb 4.7kΩ 10% ¼W	24341-300
R3	Carb 100kΩ 10% ¼W	24341-335
R4	Carb 1MΩ 1% ¼W	24145-601
R5	Carb 4.7kΩ 10% ¼W	24341-300
R6	Carb 100kΩ 10% ½W	24342-135
R7	Carb 100kΩ 10% ½W	24342-135
R9	Carb 100Ω 10% ¼W	24341-250
R11	Carb 10kΩ 10% ¼W	24342-110

Circuit reference	Description	M.I. code
RV1	Carb 10kΩ 10% ¼W	44371-237
RV3	Carb 12kΩ 10%	44371-229
RV4	Carb a) 10kΩ 20% ¼W b) 1kΩ	44371-233
RV5	Carb a) 5kΩ 20% ¼W b) 5kΩ	44371-234
NOTE.	For details of the TIME/CM switch see SA on Unit A15.	
SE	AUTO-DC-AC switch	44322-137
SF	SLOPE switch	44321-138
SG	SOURCE switch	44322-136
SH	MAGnifier switch	23467-127
SKTH	50Ω BNC	23443-443
SKTK	2mm Black	23421-127
SKTL	2mm Red	23421-126
SKTJ	50Ω BNC	23443-443
SKTM	24 way	23435-639
SKTN	24 way	23435-639

A9 Single sweep unit interconnection (Fig. 7.7)

C1	Paper 0.01μF 10% 400V	26174-145
ILP1	6V 70mA amber	23746-701
R1	Met ox 100Ω 5%	24581-216
SA	RESET button	23465-156
SB	SWEEP switch	44321-138
SKTS	24 way	23435-639
SKTT	24 way	23435-639

A10 A sweep unblanking generator, single shot and gated delay (Fig. 7.8)

C1	Plas 220pF 2% 125V	26516-327
C2	Cer 47pF 2% 750V	26324-833
C3	Plas 220pF 2% 125V	26516-327
C4	Cer 47pF 2% 750V	26324-833
C5	Paper 0.01μF 10% 200V	26174-145
C6	Cer 0.1μF +50-20% 30V	26383-031
C7	Cer 0.1μF +50-25% 30V	26383-031
C8	Cer 100pF 2% 750V	26324-897
C9	Cer 47pF 2% 750V	26324-833
C10	Cer 100pF 2% 750V	26324-897
C11	Cer 100pF 2% 750V	26324-897
C12	Cer 47pF 2% 750V	26324-833
C13	Cer 0.1μF +50-25% 30V	26383-031
C14	Cer 0.1μF +50-25% 30V	26383-031
MR1	Texas Inst. 1S44	28357-548
MR2	Texas Inst. 1S44	28357-548
MR3	Texas Inst. 1S44	28357-548
MR4	Texas Inst. 1S44	28357-548
MR5	Texas Inst. 1S44	28357-548
MR6	Texas Inst. 1S44	28357-548
MR7	Texas Inst. 1S44	28357-548
MR8	Texas Inst. 1S44	28357-548
R1	Met ox 470Ω 5% ½W	24552-069
R2	Carb 4.7kΩ 10% ¼W	24341-300
R3	Carb 2.7kΩ 10% ¼W	24341-292
R4	Met ox 1.8kΩ 5% ½W	24552-086
R5	Met ox 33kΩ 5% ½W	24552-122
R6	Met ox 33kΩ 5% ½W	24552-122
R7	Met ox 1.8kΩ 5% ½W	24552-086
R8	Carb 4.7kΩ 10% ¼W	24341-300
R9	Met ox 470Ω 5% ½W	24552-069
R10	Carb 4.7kΩ 10% ¼W	24341-300
R11	Carb 33kΩ 10% ¼W	24341-322
R12	Carb 10MΩ 10% ½W	24342-191
R13	Carb 47Ω 10% ½W	24342-037
R14	Carb 68Ω 10% ½W	24342-043
R15	Met ox 15kΩ 5% ½W	24552-114
R16	Met ox 3.3kΩ 5% ½W	24552-094
R17	Met ox 330Ω 5% ½W	24552-063
R18	Met ox 120Ω 5% ½W	24552-052
R19	Met ox 820Ω 5% ½W	24552-078
R20	Met ox 220Ω 5% ½W	24552-058

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R21	Met ox 47Ω 5% ½W	24552-037
R22	Carb 47Ω 10% ½W	24342-037
R23	Met ox 4.7kΩ 5% ½W	24552-100
R24	Carb 1kΩ 10% ½W	24342-080
R25	Carb 2.2kΩ 10% ½W	24342-088
R26	Carb 47Ω 10% ¼W	24341-237
R27	Met ox 200Ω 5% ½W	24552-057
R28	Met ox 470Ω 5% ½W	24552-069
R29	Carb 2.2kΩ 10% ½W	24341-288
R30	Met ox 1.8kΩ 5% ½W	24552-086
R31	Met ox 33kΩ 5% ½W	24552-122
R32	Carb 2.2kΩ 10% ¼W	24341-288
R33	Met ox 33kΩ 5% ½W	24552-122
R34	Carb 2.2kΩ 10% ¼W	24341-288
R35	Met ox 1.8kΩ 5% ½W	24552-086
R36	Carb 2.7kΩ 10% ¼W	24341-292
R37	Met ox 470Ω 5% ½W	24552-069
R38	Carb 47Ω 10% ¼W	24341-237
R39	Carb 27kΩ 10% ½W	24342-120
R40	Carb 33Ω 10% ¼W	24341-233
VT1	General purpose n-p-n	28452-197
VT2	General purpose n-p-n	28452-197
VT3	General purpose n-p-n	28452-787
VT4	Motorola MPS3640	28431-766
VT5	General purpose n-p-n	28452-197
VT6	General purpose n-p-n	28452-787
VT7	High voltage n-p-n	44522-018
VT8	General purpose n-p-n	28452-197
VT9	General purpose n-p-n	28452-197

A11 Delay pick-off (Fig. 7.9)

C1	Cer 4.7pF 0.25pF 750V	26324-017
C2	Cer 0.1μF +50-25% 30V	26383-031
C3	Plas 0.1μF 10% 250V	26582-208
C4	Elec 12μF +100-20% 50V	26423-309
C5	Cer 68pF 2% 750V	26324-868
C6	Cer 0.1μF +50-25% 30V	26383-031
C7	Cer 100pF 2% 750V	26324-897
C8	Cer 100pF 2% 750V	26324-897
C9	Cer 47pF 2% 750V	26324-833
C10	Cer 47pF 2% 750V	26324-833
C11	Cer 68pF 2% 750V	26324-868
C12	Cer 100pF 2% 750V	26324-897
C13	Cer 100pF 2% 750V	26324-897
C14	Cer 47pF 2% 750V	26324-833
C15	Cer 47pF 2% 750V	26324-833
C16	Cer 0.01μF +50-20% 100V	26383-055
C17	Cer 0.01μF +50-20% 100V	26383-055
MR1	Texas Inst. 1S44	28357-548
MR2	Texas Inst. 1S44	28357-548
MR3	Zener diode	28371-440
MR4	Texas Inst. 1S44	28357-548
MR5	Texas Inst. 1S44	28357-548
MR6	Texas Inst. 1S44	28357-548
MR7	Texas Inst. 1S44	28357-548
MR8	Texas Inst. 1S44	28357-548
MR9	Texas Inst. 1S44	28357-548
MR10	Texas Inst. 1S44	28357-548
MR11	Texas Inst. 1S44	28357-548
MR12	Texas Inst. 1S44	28357-548
MR13	Texas Inst. 1S44	28357-548
MR14	Texas Inst. 1S44	28357-548
MR15	Texas Inst. 1S44	28357-548
MR16	Texas Inst. 1S44	28357-548
MR17	Texas Inst. 1S44	28357-548
MR18	Zener diode	28371-440
R1	Carb 4.7kΩ 10% ½W	24342-100
R2	Met ox 47kΩ 5% ½W	24552-126
R3	Met ox 1.2kΩ 5% ½W	24552-082
R4	Met ox 1kΩ 5% ¼W	24581-240
R5	Met ox 12kΩ 5% 1W	24585-152
R6	Carb 100Ω 10% ¼W	24341-250
R7	Met ox 1kΩ 5% ¼W	24581-240
R8	Met ox 4.7kΩ 5% ¼W	24581-256
R9	Met ox 11kΩ 5% ¼W	24581-265
R10	Carb 47Ω 10% ¼W	24341-237
R11	Met ox 3.3kΩ 5% 2W	24587-238
R12	Met 22.1kΩ 1% ¼W	24765-725

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R13	Met 43.2kΩ 1% ¼W	24765-718
R14	Met ox 2.7kΩ 5% ½W	24552-092
R15	Met ox 7.5kΩ 5% ½W	24552-107
R16	Carb 6.8kΩ 10% ¼W	24341-306
R17	Carb 15kΩ 10% ¼W	24341-314
R18	Met ox 10kΩ 5% ¼W	24581-264
R19	Met ox 680Ω 5% ¼W	24581-236
R20	Carb 47Ω 10% ¼W	24341-237
R21	Met ox 1kΩ 5% ¼W	24581-240
R22	Carb 15kΩ 10% ¼W	24341-314
R23	Carb 1kΩ 10% ½W	24342-080
R24	Carb 3.3kΩ 10% ½W	24342-094
R25	Carb 2.2kΩ 10% ¼W	24341-288
R26	Met ox 1.2kΩ 5% ¼W	24581-241
R27	Carb 2.2kΩ 10% ¼W	24341-288
R28	Met ox 1.8kΩ 5% ¼W	24581-246
R29	Carb 2.7kΩ 10% ¼W	24341-292
R30	Met ox 33kΩ 5% ¼W	24581-276
R31	Met ox 33kΩ 5% ¼W	24581-276
R32	Carb 2.7kΩ 10% ¼W	24341-292
R33	Met ox 1.8kΩ 5% ¼W	24581-246
R34	Carb 2.2kΩ 10% ¼W	24341-288
R35	Met ox 1.2kΩ 5% ¼W	24581-241
R36	Carb 4.7kΩ 10% ¼W	24341-300
R37	Carb 5.6kΩ 10% ¼W	24341-303
R38	Carb 2.2kΩ 10% ¼W	24341-288
R39	Carb 6.8kΩ 10% ¼W	24341-306
R40	Carb 3.3kΩ 10% ¼W	24341-294
R41	Carb 3.3kΩ 10% ½W	24342-094
R42	Met ox 750Ω 5% ¼W	24581-237
R43	Met ox 1.8kΩ 5% ½W	24552-086
R44	Met ox 470Ω 5% ¼W	24581-232
R45	Carb 2.2kΩ 10% ¼W	24341-288
R46	Met ox 1.8kΩ 5% ¼W	24581-246
R47	Met ox 33kΩ 5% ¼W	24581-276
R48	Met ox 33kΩ 5% ¼W	24581-276
R49	Met ox 1.8kΩ 5% ¼W	24581-246
R50	Carb 2.2kΩ 10% ¼W	24341-288
R51	Met ox 470Ω 5% ¼W	24581-232
R52	Met ox 510Ω 5% ¼W	24581-233
R53	Met ox 1.5kΩ 5% ½W	24552-084
R54	Carb 100Ω 10% ¼W	24341-250
R55	Met 249Ω 1% 1/8W	24763-459
R56	Carb 100Ω 10% ¼W	24341-250
R57	Carb 150Ω 10% ¼W	24341-254
RV1	WW 1kΩ 10% ¼W	25886-195
RV2	WW 5kΩ 10% ¼W	25886-197
VT1	Mullard BC107	28455-437
VT2	General purpose n-p-n	28452-197
VT3	General purpose n-p-n	28452-197
VT4	Mullard BC107	28455-437
VT5	Mullard BC107	28455-437
VT6	Mullard BC107	28455-437
VT7	General purpose n-p-n	28452-197
VT8	Texas Inst. 2N3702	28433-488
VT9	General purpose n-p-n	28452-787
VT10	General purpose n-p-n	28452-197
VT11	General purpose n-p-n	28452-197
VT12	Texas Inst. 2N3702	28433-488
VT13	General purpose n-p-n	28452-787
VT14	Texas Inst. 2N3702	28433-488
VT15	General purpose n-p-n	28452-197
VT16	General purpose n-p-n	28452-197
VT17	Texas Inst. 2N3702	28433-488

A12 Trigger circuits (Fig. 7.10)

C1	Cer 68pF 2% 750V	26324-868
C2	Cer 0.1μF +50-25% 30V	26383-031
C3	Cer 0.1μF +50-20% 30V	26383-031
C4	Cer 0.01μF +80-20% 100V	26383-055
C5	Elec 12μF +100-20% 15V	26423-393
C6	Elec 12μF +100-20% 15V	26423-393
C7	Cer 0.01μF +80-20% 100V	26383-055
C8	Cer 0.1μF +50-25% 30V	26383-031
C9	Cer 0.1μF +50-25% 30V	26383-031
C10	Cer 1.5pF ±0.25pF 750V	26324-008
C11	Plas 100pF 2% 125V	26516-241
C12	Elec 1μF +100-20% 50V	26414-106
C13	Elec 1μF +100-20% 50V	26414-106

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
C14	Elec 1μF +100–20% 50V	26414-106
C15	Plas 0.1pF +50–20% 250V	26582-208
C16	Elec 1μF +100–20% 50V	26414-106
C17	Plas 680pF 2% 125V	26516-444
C18	Plas 200pF 2% 125V	26516-315
C19	Plas 200pF 2% 125V	26516-315
L1	Inductor	44245-207
L2	Inductor	44225-209
MR1	Texas Inst. 1S44	28357-548
MR2	Texas Inst. 1S44	28357-548
MR3	Gen. Electric 1N3719	28383-320
MR4	Texas Inst. 1S44	28357-548
MR5	Texas Inst. 1S44	28357-548
MR6	Texas Inst. 1S44	28357-548
MR7	Texas Inst. 1S44	28357-548
MR8	Texas Inst. 1S44	28357-548
R1	Carb 47Ω 10% ¼W	24341-237
R2	Carb 47Ω 10% ¼W	24341-237
R3	Met ox 8.2kΩ 5% ¼W	24581-262
R4	Met ox 2.7kΩ 5% ¼W	24581-250
R5	Met ox 2.7kΩ 5% ¼W	24581-250
R6	Carb 22Ω 10% ¼W	24341-228
R7	Carb 47Ω 10% ¼W	24341-237
R8	Met ox 2.7kΩ 5% ¼W	24581-250
R9	Met ox 1.5kΩ 5% ¼W	24581-244
R10	Met ox 620Ω 5% ¼W	24581-244
R11	Carb 220Ω 10% ¼W	24341-258
R12	Met ox 620Ω 5% ¼W	24581-244
R13	Met ox 1.5kΩ 5% ¼W	24581-244
R14	Carb 100Ω 10% ¼W	24341-250
R15	Carb 1kΩ 10% ¼W	24341-280
R16	Carb 470Ω 10% ¼W	24341-269
R19	Carb 470Ω 10% ¼W	24341-269
R20	Carb 1kΩ 10% ¼W	24341-280
R21	Carb 100Ω 10% ¼W	24341-250
R22	Carb 3.3kΩ 10% ¼W	24341-294
R23	Carb 3.3kΩ 10% ¼W	24341-294
R24	Carb 47Ω 10% ¼W	24341-237

Circuit reference	Description	M.I. code
R25	Carb 1.5kΩ 10% ½W	24342-084
R26	Met ox 180Ω 5% ¼W	24581-222
R27	Met ox 22Ω 5% ¼W	24581-203
R28	Met ox 22Ω 5% ¼W	24581-203
R29	Met ox 180Ω 5% ¼W	24581-222
R30	Carb 47Ω 10% ¼W	24341-237
R31	Carb 22Ω 10% ¼W	24341-228
R32	Carb 12kΩ 10% ¼W	24341-312
R33	Met ox 82Ω 5% ¼W	24581-214
R34	Met ox 82Ω 5% ¼W	24581-214
R35	Carb 13kΩ 1% ½W	24135-130
R36	Carb 3.9kΩ 10% ½W	24342-096
R37	Carb 15kΩ 1% ½W	24135-150
R38	Carb 1.8kΩ 10% ¼W	24341-286
R39	Carb 3.9kΩ 10% ¼W	24341-296
R40	Met ox 15Ω 5% ¼W	24581-201
R41	Carb 680Ω 10% ½W	24342-076
R42	Carb 1kΩ 10% ½W	24342-080
R43	Carb 10kΩ 10% ¼W	24341-310
R44	Met ox 33Ω 1% ¼W	24522-233
R45	Carb 22kΩ 10% ¼W	24341-318
R46	Carb 22kΩ 10% ¼W	24341-318
R47	Carb 220Ω 10% ¼W	24341-258
R48	Carb 27kΩ 10% ¼W	24341-320
R49	Carb 1.5kΩ 10% ¼W	24341-284
R50	Carb 390Ω 10% ¼W	24341-265
R51	Carb 47kΩ 10% ¼W	24341-326
R52	Carb 47kΩ 10% ¼W	24341-326
R53	Carb 220Ω 10% ¼W	24341-258
R54	Carb 1kΩ 10% ¼W	24341-280
R55	Carb 3.65kΩ 1% ½W	24134-365
R56	Carb 12kΩ 1% ½W	24135-120
R57	Met ox 9.1kΩ 5% ½W*	24552-109
R58	Carb 4.7kΩ 10% ¼W	24341-300
R59	Carb 33kΩ 10% ¼W	24341-322
R60	Carb 15kΩ 10% ¼W	24341-314
R61	Carb 15kΩ 10% ¼W	24341-314
R62	Carb 4.7kΩ 10% ¼W	24341-300
R63	Met ox 2.7kΩ 5% ¼W	24581-250
R64	Met ox 33kΩ 5% ¼W	24581-276
R65	Met ox 2.7kΩ 5% ¼W	24581-250

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R66	Met ox 10kΩ 5% ¼W	24581-264
R67	Met ox 3kΩ 5% ¼W	24581-251
R68	Carb 220Ω 10% ¼W	24341-258
R69	Carb 47Ω 10% ¼W	24341-237
R70	Met ox 100Ω 5% ¼W	24581-261
RV1	Carb 2.5kΩ 20% ¼W	25541-222
RV2	Carb 1kΩ 20% ¼W	25541-219
RV3	Carb 1kΩ 20% ¼W	25541-219
RV4	Carb 2.5kΩ 20% ¼W	25541-222
T1	Transformer	44236-007
VT1	Motorola MPS3640	28431-766
VT2	Motorola MPS3640	28431-766
VT3	Low noise n-p-n	28452-777
VT4	Low noise n-p-n	28452-777
VT5	General purpose n-p-n	28452-197
VT6	General purpose n-p-n	28452-197
VT7	General purpose n-p-n	28452-197
VT8	General purpose n-p-n	28452-197
VT9	Mullard BC107	28455-437
VT10	Texas Inst. 2N3702	28433-488
VT11	Texas Inst. 2N3702	28433-488
VT12	Mullard BC107	28455-437
VT13	Mullard BC107	28455-437
VT14	Motorola 2N3906	28434-856
VT15	Texas Inst. 2N3702	28433-488
VT16	Mullard BC107	28455-437
VT17	Union Carbide 2N4392	28459-002
VT18	Mullard BC107	28455-437

A13 Horizontal amplifier (Fig. 7.11)

Circuit reference	Description	M.I. code
C1	Cer 0.01μF +80-20% 100V	26383-055
C2	Paper 0.002μF 10% 350V	26174-129
C3	Cer 0.01μF +80-20% 100V	26383-055
C4	Cer 4.7pF ±0.25pF 750V	26324-017
C5	Elec 2μF +100-20% 25V	26414-109
C6	Cer 0.1μF +50-25% 30V	26383-031
C7	Plas 47pF ±2pF 125V	26516-165
C8	Plas 0.1μF 10% 250V	26582-208
C9	Elec 25μF +100-20% 18V	26417-141
C10	Cer 0.1μF +50-25% 30V	26383-031
C11	Cer 0.1μF +50-25% 30V	26383-031
C12	Cer 0.01μF +80-20% 100V	26383-055
C13	Cer 0.1μF +50-25% 30V	26383-031
C14	Cer 0.01μF +80-20% 100V	26383-055
C15	Cer 0.01μF +80-20% 100V	26383-055
C16	Cer 68pF 2% 750V	26324-868
MR1	Texas Inst. 1S44	28357-548
MR2	Texas Inst. 1S44	28357-548
MR3	Texas Inst. 1S44	28357-548
MR4	Fairchild BAY82	28335-186
MR5	Fairchild BAY82	28335-186
MR6	Texas Inst. 1S44	28357-548
MR7	Texas Inst. 1S44	28357-548
MR8	Texas Inst. 1S44	28357-548
R1	Carb 10kΩ 1% ¼W	24135-100
R2	Carb 47Ω 10% ¼W	24341-237
R3	Carb 82kΩ 1% ¼W	24135-820
R4	Carb 8.2kΩ 1% ¼W	24134-820
R5	Carb 47Ω 10% ¼W	24341-237
R6	Carb 27kΩ 10% ¼W	24341-320
R7	Carb 47Ω 10% ¼W	24341-237
R8	Met 5.1kΩ 1% ½W	24765-701
R9	Met ox 43kΩ 5% ¼W	24581-279
R10	Met 10kΩ 1% ½W	24765-710
R11	Met 3.6kΩ 1% ½W	24765-695
R12	Carb 390Ω 10% ¼W	24341-265
R13	Carb 750Ω 1% ¼W	24133-750
R14	Carb 22Ω 10% ¼W	24341-228
R15	Met ox 2.4kΩ 5% ½W	24552-089
R16	Carb 560Ω 10% ½W	24341-272
R17	Carb 36kΩ 1% ¼W	24135-360
R18	Carb 18kΩ 1% ¼W	24135-180
R19	Carb 47Ω 10% ¼W	24341-237
R20	Met 5.6kΩ 1% ½W	24765-703
R21	Carb 330Ω 10% ¼W	24341-263
R22	Carb 7.87kΩ 1% ½W	24154-787
R23	Carb 39Ω 10% ¼W	24341-235

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R24	Met 3kΩ 1% 1/8W	24763-493
R25	Met 560Ω 1% 1/8W	24763-472
R26	Met 300Ω 1% 1/8W	24763-462
R27	Met 2.2kΩ 1% 1/8W	24763-488
R28	Met 510Ω 1% 1/8W	24763-470
R29	Carb 4.7kΩ 1% ¼W	24134-470
R30	Met ox 5.6kΩ 5% ½W	24552-103
R31	Carb 470Ω 10% ¼W	24341-269
R32	Carb 2.4kΩ 1% ¼W	24134-240
R33	Carb 7.8kΩ 1% ¼W	24134-787
R34	Carb 47Ω 10% ¼W	24341-237
R35	Carb 4.3kΩ 1% ¼W	24134-430
R36	Carb 4.7kΩ 1% ¼W	24134-470
R37	Carb 11kΩ 5% ¼W	24232-111
R38	Carb 120Ω 10% ¼W	24341-252
R39	Carb 220Ω 10% ¼W	24341-258
R40	Met 1.8kΩ 1% ½W	24765-686
R41	**Met ox 2.2kΩ 5% ¼W**	**24581-248**
R42	Carb 560Ω 10% ¼W	24341-272
R43	Met ox 3.9kΩ 5% 1W	24585-140
R44	**Carb 47Ω 10% ¼W**	**24341-237**
R45	Carb 39Ω 10% ¼W	24341-235
R46	Carb 180Ω 1% ¼W	24133-180
R47	Carb 150Ω 5% ¼W	24232-054
R48	Carb 10Ω 10% ¼W	24341-220
R49	Carb 470Ω 1% ½W	24133-470
R50	**Carb 47Ω 10% ¼W**	**24341-237**
R51	Carb 200Ω 1% ¼W	24133-200
R52	Carb 750Ω 1% ¼W	24133-750
R53	Carb 560Ω 1% ¼W	24133-560
R55	Carb 10kΩ 10% ¼W	24341-310
R56	Carb 220Ω 10% ¼W	24341-258
R57	Carb 47kΩ 10% ¼W	24341-326
R58	Met ox 4.7kΩ 5% 1W	24585-142
R59	Carb 10Ω 10% ¼W	24341-220
R60	Carb 470Ω 10% ¼W	24341-269
RV1	Carb 100Ω 10%	24551-266
RV2	Carb 100Ω 10%	24551-266
RV3	Carb 10kΩ 20%	24551-233
RV4	Carb 200Ω 10%	24551-267

Circuit reference	Description	M.I. code
VT1	Mullard BC107	28455-437
VT2	Mullard BC107	28455-437
VT3	Mullard BC107	28455-437
VT4	Mullard BC107	28455-437
VT5	Low noise n-p-n	28452-777
VT6	General purpose p-n-p	28433-487
VT7	General purpose p-n-p	28433-487
VT8	General purpose n-p-n	28452-787
VT9	General purpose p-n-p	28433-487
VT10	General purpose n-p-n	28452-197
VT11	General purpose n-p-n	28452-787
VT12	General purpose n-p-n	28452-197
A14	**Sweep circuits (Fig. 7.12)**	
C1	Cer 68pF 2% 750V	26324-868
C2	Cer 0.1μF +50-25% 30V	26383-031
C3	Cer 100pF 2% 750V	26324-897
C4	Plas 220pF 2% 125V	26516-327
C5	Plas 220pF 2% 125V	26516-327
C6	Cer 0.1μF +50-20% 30V	26383-031
C7	Cer 68pF 2% 750V	26324-868
C8	Cer 0.1μF +50-25% 30V	26383-031
C9	Cer 100pF 2% 750V	26324-897
C10	Cer 47pF 2% 750V	26324-833
C11	Cer 8.2pF ±0.25pF 750V	26324-708
C12	Cer 0.1μF +50-25% 30V	26383-031
C13	Cer 68pF 2% 750V	26324-868
C14	Elec 4μF +100-20% 50V	26423-305
C15	Plas 220pF 2% 125V	26516-327
C16	Elec 4μF +100-20% 50V	26423-305
C17	Elec 50μF +100-20% 25V	26423-317
C18	Paper 500pF 20% 600V	26174-122
C19	Cer 0.1μF +50-25% 30V	26383-031
C20	Cer 0.1μF +50-25% 30V	26383-031
C21	Cer 0.1μF +50-25% 30V	26383-031
C22	Cer 0.1μF +50-25% 30V	26383-031
C23	Cer 3.3pF ±0.25pF 750V	26324-014
C24	**Cer 68pF 2% 750V**	**26324-868**
C25	**Plas 100pF ±2pF 125V**	**26516-241**
C26	**Cer 0.01μF +80-20% 100V**	**26383-055**
MR1	Texas Inst. 1S44	28357-548

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
MR2	Texas Inst. 1S44	28357-548
MR3	Texas Inst. 1S44	28357-548
MR4	Texas Inst. 1S44	28357-548
MR5	Texas Inst. 1S44	28357-548
MR6	Texas Inst. 1S44	28357-548
MR7	Texas Inst. 1S44	28357-548
MR8	Texas Inst. 1S44	28357-548
MR9	Texas Inst. 1S44	28357-548
MR10	Texas Inst. 1S44	28357-548
MR11	Texas Inst. 1S44	28357-548
MR12	Silicon diode	28336-676
MR13	Texas Inst. 1S44	28357-548
R1	Carb 10kΩ 10% ¼W	24341-310
R2	Met ox 100Ω 5% ½W*	24552-050
R3	Carb 1kΩ 10% ¼W	24341-280
R4	Met ox 750Ω 5% ¼W	24581-237
R5	Met ox 15kΩ 5% ¼W	24581-268
R6	Carb 100kΩ 10% ¼W	24341-335
R7	Carb 100Ω 10% ¼W	24341-250
R8	Carb 330Ω 10% ¼W	24341-263
R9	Carb 100Ω 10% ¼W	24341-250
R10	Carb 4.7kΩ 10% ¼W	24341-300
R11	Met ox 100Ω 5% ¼W	24581-216
R12	Met ox 1kΩ 1% ¼W	24522-280
R13	Carb 47Ω 10% ¼W	24341-237
R14	Met ox 10kΩ 5% ½W	24552-110
R15	Met ox 5.6kΩ 1% ¼W	24522-303
R16	Met ox 2.7kΩ 1% ¼W	24522-292
R17	Carb 1.8kΩ 10% ½W	24342-086
R18	Met ox 330Ω 1% ¼W	24522-263
R19	Met ox 33kΩ 5% ¼W	24581-276
R20	Carb 470Ω 10% ¼W	24341-269
R21	Met ox 1kΩ 1% ¼W	24522-280
R22	Met ox 6.8kΩ 1% ¼W	24522-306
R23	Met ox 1.8kΩ 1% ¼W	24522-286
R24	Met ox 1.5kΩ 1% ¼W	24522-284
R25	Met ox 15kΩ 5% ¼W	24581-268
R26	Met ox 16kΩ 5% ¼W	24581-269
R27	Met ox 18kΩ 5% ½W	24552-116
R28	Carb 47kΩ 10% ¼W	24341-326
R29	Carb 47kΩ 10% ¼W	24341-326
R30	Carb 22kΩ 10% ¼W	24341-318
R31	Carb 1.8kΩ 10% ¼W	24341-286
R32	Carb 5.6kΩ 10% ¼W	24341-303
R33	Carb 100Ω 10% ¼W	24341-250
R34	Met ox 5.6kΩ 1% ¼W	24522-303
R35	Met ox 2.7kΩ 1% ¼W	24522-292
R36	Met ox 10kΩ 5% ¼W	24581-264
R37	Carb 22Ω 10% ¼W	24341-228
R38	Carb 10kΩ 10% ½W	24342-110
R39	Carb 100Ω 10% ¼W	24341-250
R40	Carb 2.2kΩ 10% ¼W	24341-288
R41	Carb 470Ω 10% ½W	24342-069
R42	Carb 47Ω 10% ¼W	24341-237
R43	Met ox 10kΩ 5% ½W*	24552-110
R44	Carb 100Ω 10% ¼W	24341-250
R45	Met ox 6.8kΩ 5% 2W	24587-246
R46	Carb 47Ω 10% ¼W	24341-237
R47	Met ox 24kΩ 5% ¼W	24581-273
R48	Met ox 6.2kΩ 5% ¼W	24581-259
R49	Carb 22Ω 10% ¼W	24341-228
R50	Carb 2.2kΩ 10% ½W	24342-088
R51	Met ox 200Ω 5% ½W*	24552-057
R52	Met ox 300Ω 1% ¼W*	24512-362
R53	Carb 33Ω 10% ¼W	24341-233
R54	Carb 100Ω 10% ¼W	24341-250
R55	Carb 1.5kΩ 10% ¼W	24341-284
R56	Carb 1kΩ 10% ¼W	24341-280
R57	Carb 220Ω 10% ¼W	24341-258
T1	Transformer	44236-008
V1	Nuvistor	28127-488
VT1	General purpose n-p-n	28452-197
VT2	Texas Inst. 2N3702	28433-488
VT3	General purpose n-p-n	28452-197
VT4	General purpose n-p-n	28452-197
VT5	General purpose n-p-n	28452-197
VT6	General purpose n-p-n	28452-197

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
VT7	General purpose n-p-n	28452-197
VT8	Mullard BCY70	28434-857
VT9	Mullard BCY72	28433-487
VT10	General purpose n-p-n	28452-787
VT11	Motorola MM1613	28454-776
VT12	High voltage n-p-n	44522-018
VT13	General purpose n-p-n	28452-787

A15 TIME/CM switch circuitry (Fig. 7.10)

C1	Plas 5μF 5% 160V	26581-280
C2	Plas 1μF 5% 63V	26551-254
C3	Plas 0.1μF 1.25% 63V	26511-804
C4	Plas 0.01μF 1.25% 63V	26511-803
C5	Plas 0.001μF 1.25% 63V	26511-802
C6	Plas 82pF 1.25% 63V	26511-801
C7	Cer 6-30pF	26847-448
C8	Elec 1μF +100-20% 50V	26414-106
C9	Plas 0.1μF 10% 250V	26515-228
C10	Paper 0.01μF 10% 200V	26174-145
C11	Paper 0.005μF 10% 250V	26174-141
C12	Cer 100pF 2% 750V	26324-897
C13	Cer 68pF 2% 750V	26324-868
R1	Met 1.8MΩ 0.25% ½W	24735-772
R2	Met 360kΩ 0.25% ¼W	24735-549
R3	Met 180kΩ 0.25% ½W	24735-541
R4	Met 36kΩ 0.25% ½W	24735-523
R5	Met 18kΩ 0.25% ½W	24735-516
R6	Met 720kΩ 0.25% ½W	24735-559
R7	Met 72kΩ 0.25% ½W	24735-532
R8	Met 90kΩ 0.25% ½W	24735-534
R9	Met 9kΩ 0.25% ½W	24735-509
R10	Met 1.8MΩ 0.25% ½W	24735-772
R11	Carb 47Ω 10% ½W	24342-037
R12	Met ox 6.8kΩ 5% ½W*	24552-106
R13	Met ox 1.8kΩ 5% ½W	24552-086
R14	Met ox 12kΩ 5% ½W	24552-112
R15	Met ox 2.7kΩ 5% ½W	24552-092
SA	TIME/CM switch	44328-005

A16 Trigger gates and aiming potential (Fig. 7.12)

C1	Cer 0.01μF +80-20% 100V	26383-055
MR1	Texas Inst. 1S44	28357-548
MR2	Texas Inst. 1S44	28357-548
MR3	Texas Inst. 1S44	28357-548
MR4	Texas Inst. 1S44	28357-548
MR5	Texas Inst. 1S44	28357-548
MR6	Texas Inst. 1S44	28357 548
MR7	Texas Inst. 1S44	28357-548
MR8	Texas Inst. 1S44	28357-548
R1	Met ox 8.2kΩ 5% ½W*	24552-108
R2	Carb 22kΩ 10% ½W	24342- 18
R3	Carb 47kΩ 10% ¼W	24341-326
R4	Carb 4.7kΩ 10% ¼W	24341-300
R5	Carb 150Ω 10% ¼W	24341-254
R6	Met ox 22kΩ 5% ½W*	24552-118
R7	Carb 47Ω 10% ¼W	24341-237
R8	Carb 47Ω 10% ¼W	24341-237
R9	Met ox 390Ω 5% ½W*	24552-065
R10	Carb 100Ω 10% ¼W	24341-250
R12	Met ox 470Ω 5% ½W*	24552-069
R13	Met 4.81kΩ 0.5% ½W	24755-700
R14	Met ox 470Ω 5% ½W*	24552-069
R15	Met 845Ω 0.5% ¼W	24755-478
R16	Met ox 200Ω 5% ½W*	24552-057
R17	Met ox 200Ω 5% ½W*	24552-057
R18	Met ox 200Ω 5% ½W*	24552-057
R19	Carb 47kΩ 10% ¼W	24341-326

For symbols and abbreviations see Introduction to this chapter

Circuit reference	Description	M.I. code
RV1	Carb 1kΩ 20%	25541-371
RV2	Carb 1kΩ 20%	25541-371
RV3	Carb 500Ω 10%	25541-369
RV4	Carb 500Ω 10%	25541-369
RV5	Carb 500Ω 10%	25541-369
VT1	Motorola MPS3640	28431-766
VT2	Mullard 2N2904	28434-878
VT3	BC 107	28455-437
VT4	General purpose n-p-n	28452-787

A17 B sweep unblanking generator, high level sweep gates (Fig. 7.8)

C1	Cer 47pF 2% 750V	26324-833
C2	Cer 47pF 2% 750V	26324-833
C3	Cer 0.1μF +50-25% 30V	26383-031
C4	Cer 0.1μF +50-25% 30V	26383-031
C5	Cer 0.1μF +50-25% 30V	26383-031
C6	Cer 0.1μF +50-25% 30V	26383-031
MR1	Texas Inst. 1S44	28357-548
MR2	Texas Inst. 1S44	28357-548
MR3	Texas Inst. 1S44	28357-548
MR4	Texas Inst. 1S44	28357-548
MR5	Texas Inst. 1S44	28357-548
MR6	Texas Inst. 1S44	28357-548
MR7	Texas Inst. 1S44	28357-548
R1	Met ox 1.5kΩ 5% ½W	24552-084
R2	Met ox 1.5kΩ 5% ½W	24552-084
R3	Met ox 15kΩ 5% ½W	24552-114
R4	Met ox 15kΩ 5% ½W	24552-114
R5	Met ox 18kΩ 5% 1W	24585-156
R6	Met ox 18kΩ 5% 1W	24585-156
R7	Met ox 47kΩ 5% ½W	24552-126
R8	Met ox 3.3kΩ 5% ½W	24552-094
R9	Carb 1.5kΩ 10% ½W	24342-170
R10	Met ox 15kΩ 5% ½W	24552-114
R11	Met ox 330Ω 5% ½W	24552-063
R12	Met ox 120Ω 5% ½W	24552-052
R13	Met ox 820Ω 5% ½W	24552-078
R14	Met ox 220Ω 5% ½W	24552-058
R15	Met ox 47Ω 5% ½W	24552-037
R16	Carb 47Ω 10% ¼W	24341-237
R17	Met ox 4.7kΩ 5% ½W	24552-100
R18	Carb 1kΩ 10% ½W	24342-080
R19	Carb 47Ω 10% ¼W	24341-237
R20	Carb 2.2kΩ 10% ½W	24342-088
R21	Carb 47Ω 10% ¼W	24341-237
R22	Met ox 200Ω 5% ½W	24552-057
R24	Carb 10kΩ 10% ¼W	24342-110
VT1	Motorola MM1613	28454-776
VT2	Motorola MM1613	28454-776
VT3	Motorola MPS3640	28431-766
VT4	General purpose n-p-n	28452-197
VT5	General purpose n-p-n	28452-787
VT6	High voltage n-p-n	44522-018

A18 Single sweep unit circuit (Fig. 7.7)

C2	Paper 0.01μF 10% 200V	26174-145
C3	Plas 220pF 2% 125V	26516-327
C4	Cer 47pF 2% 750V	26324-833
C5	Cer 47pF 2% 750V	26324-833
C6	Plas 220pF 2% 125V	26516-327
C7	Cer 100pF 2% 750V	26324-897
C8	Cer 47pF 2% 750V	26324-833
C9	Cer 47pF 2% 750V	26324-833
C10	Cer 100pF 2% 750V	26324-897
MR1	Texas Inst. 1S44	28357-548
MR2	Texas Inst. 1S44	28357-548
MR3	Texas Inst. 1S44	28357-548
MR4	Texas Inst. 1S44	28357-548

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R1	Carb 68Ω 10% ½W	24342-043
R2	Carb 10MΩ 10% ½W	24342-191
R3	Carb 47Ω 10% ½W	24342-037
R4	Carb 33kΩ 10% ½W	24342-122
R5	Carb 4.7kΩ 10% ½W	24342-100
R6	Carb 4.7kΩ 10% ½W	24342-100
R7	Met ox 470Ω 5% ½W	24552-069
R8	Met ox 1.8kΩ 5% ½W	24552-086
R9	Met ox 33kΩ 5% ½W	24552-122
R10	Met ox 33kΩ 5% ½W	24552-122
R11	Met ox 1.8kΩ 5% ½W	24552-086
R12	Carb 2.7kΩ 10% ½W	24342-092
R13	Met ox 470Ω 5% ½W	24552-069
R14	Carb 4.7kΩ 10% ½W	24342-100
R15	Carb 2.2kΩ 10% ½W	24342-088
R16	Met ox 470Ω 5% ½W	24552-069
R17	Met ox 1.8kΩ 5% ½W	24552-086
R18	Met ox 33kΩ 5% ½W	24552-122
R19	Met ox 33kΩ 5% ½W	24552-122
R20	Met ox 1.8kΩ 5% ½W	24552-086
R21	Met ox 470Ω 5% ½W	24552-069
R22	Carb 2.2kΩ 10% ½W	24342-088
R23	Met ox 510Ω 5% ½W	24552-071
R24	Met ox 1.5kΩ 5% ½W	24552-084
VT1	General purpose n-p-n	28452-787
VT2	General purpose n-p-n	28452-197
VT3	General purpose n-p-n	28452-197
VT4	General purpose n-p-n	28452-197
VT5	General purpose n-p-n	28452-197
VT6	Texas Inst. 2N3702	28433-488

A19 Calibrator and supply indicator (Fig. 7.11)

C1	Elec 10μF +100-20% 35V	26414-121
C2	Elec 10μF +100-20% 35V	26414-121
C3	Elec 2μF +100-20% 25V	26414-109
C4	Plas 0.047μF 10% 250V	26582-206
C5	Plas 0.047μF 10% 250V	26582-206
C6	Cer 0.1μF +50-25% 30V	26383-031
C7	Cer 0.1μF +50-25% 30V	26383-031
MR1	Texas Inst. 1S44	28357-548
MR2	Texas Inst. 1S44	28357-548
MR3	Texas Inst. 1S44	28357-548
MR4	Texas Inst. 1S44	28357-548
MR5	Zener diode	28371-544
R1	Met ox 15kΩ 5% ½W	24552-114
R2	Met ox 15kΩ 5% ½W	24552-114
R3	Carb 1kΩ 10% ¼W	24341-280
R4	Met ox 8.2kΩ 5% ¼W	24581-262
R5	Met ox 6.8kΩ 5% ¼W	24581-260
R6	Met ox 68kΩ 10% ¼W	24581-284
R7	Carb 22kΩ 10% ¼W	24341-318
R8	Carb 12kΩ 10% ¼W	24341-312
R9	Met ox 4.3kΩ 5% ½W	24552-097
R10	Met ox 10kΩ 5% ½W	24552-110
R11	Carb 3.9kΩ 10% ¼W	24341-296
R12	Carb 22kΩ 10% ¼W	24341-318
R13	Carb 100kΩ 10% ¼W	24341-335
R14	Carb 1.5kΩ 10% ¼W	24341-284
R15	Carb 3.3kΩ 10% ¼W	24341-294
R16	Carb 22Ω 10% ¼W	24341-228
R17	Met ox 1kΩ 5% ½W	24552-080
R18	Carb 10kΩ 10% ¼W	24341-310
R19	Carb 10Ω 10% ¼W	24341-220
R20	Met ox 15kΩ 5% ½W	24552-114
R21	Met ox 15kΩ 5% ½W	24552-114
R22	Met ox 1kΩ 5% ½W	24552-080
R23	Carb 1kΩ 10% ¼W	24341-280
R24	Met ox 680Ω 5% ½W	24552-076
R25	Met 600Ω 0.5% ¼W	24755-473
R26	Met 2.7kΩ 0.2% ¼W	24735-492
R27	Met 270Ω 0.2% ¼W	24735-461

For symbols and abbreviations see introduction to this chapter

Circuit reference	Description	M.I. code
R28	Met 30Ω 0.2% ¼W	24735-432
R29	Met 500Ω 1% ¼W	24765-470
R30	Carb 22Ω 10% ¼W	24341-228
RV1	Carb 10kΩ 20%	25541-233
RV2	Carb 200Ω 10%	25541-267

Circuit reference	Description	M.I. code
VT1	BC 109	28452-777
VT2	General purpose n-p-n	28452-787
VT3	Motorola MPS3640	28431-766
VT4	Motorola MPS3640	28431-766
VT5	Mullard BFY51	28455-827
VT6	General purpose n-p-n	28452-787
VT7	General purpose n-p-n	28452-787
VT8	General purpose n-p-n	28452-197

For symbols and abbreviations see introduction to this chapter

Chapter 7

Circuit diagrams

Circuit notes

COMPONENT VALUES

Resistors: No suffix = ohms, k = kilohms, M = megohms.
Capacitors: No suffix = microfarads, p = picofarads.
† value selected during test, nominal value shown.

VOLTAGES

Voltage measurements made on a typical TF 2210, with a 20 kΩ/V meter, are shown in italics adjacent to the point to which the measurement refers. Vd indicates voltage which is decoupled from source voltage. The relevant control settings are given against each circuit diagram.

SYMBOLS

	arrow indicates clockwise rotation of knob.
	etc., external front panel marking.
	tag on printed board.
	test point on printed board.
1XZ	waveform code as detailed in Section 3.2.
or A10	unit identification number.

WAVEFORM DIAGRAMS

These waveform diagrams or oscillograms were taken using a TF 2210 as the monitor oscilloscope, the sweep speed and gain of which is indicated with each diagram. Where the monitor oscilloscope is externally triggered, the trigger in all cases, except where otherwise stated, is taken from the appropriate GATE OUT socket, triggering on the edge of the waveform. To obtain similar waveforms, set your oscilloscope controls as detailed in Sect. 4.4. Any variation from these positions is indicated with the particular oscillogram. Other conditions concerning the oscillograms are given on the stub of the particular circuit diagram.

CIRCUIT REFERENCES

These are, where there is a risk of ambiguity, given with the unit number.

SWITCHES

Rotary switches are drawn schematically.

1F = 1st section (front panel) front.
1B = 1st section, back.
2F = 2nd section, front.
etc.

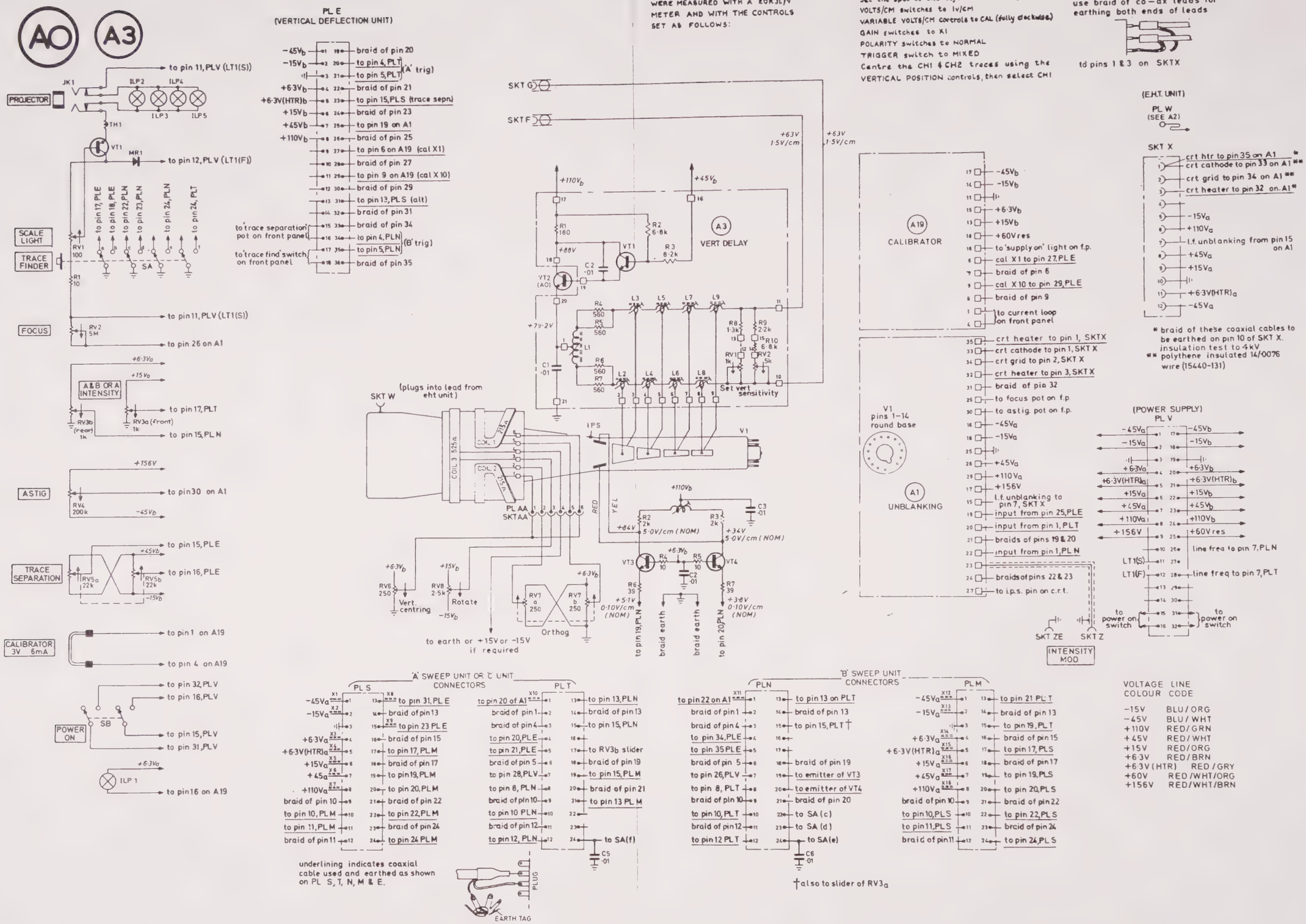


Fig. 7.1 AO : A3 General interconnection diagram

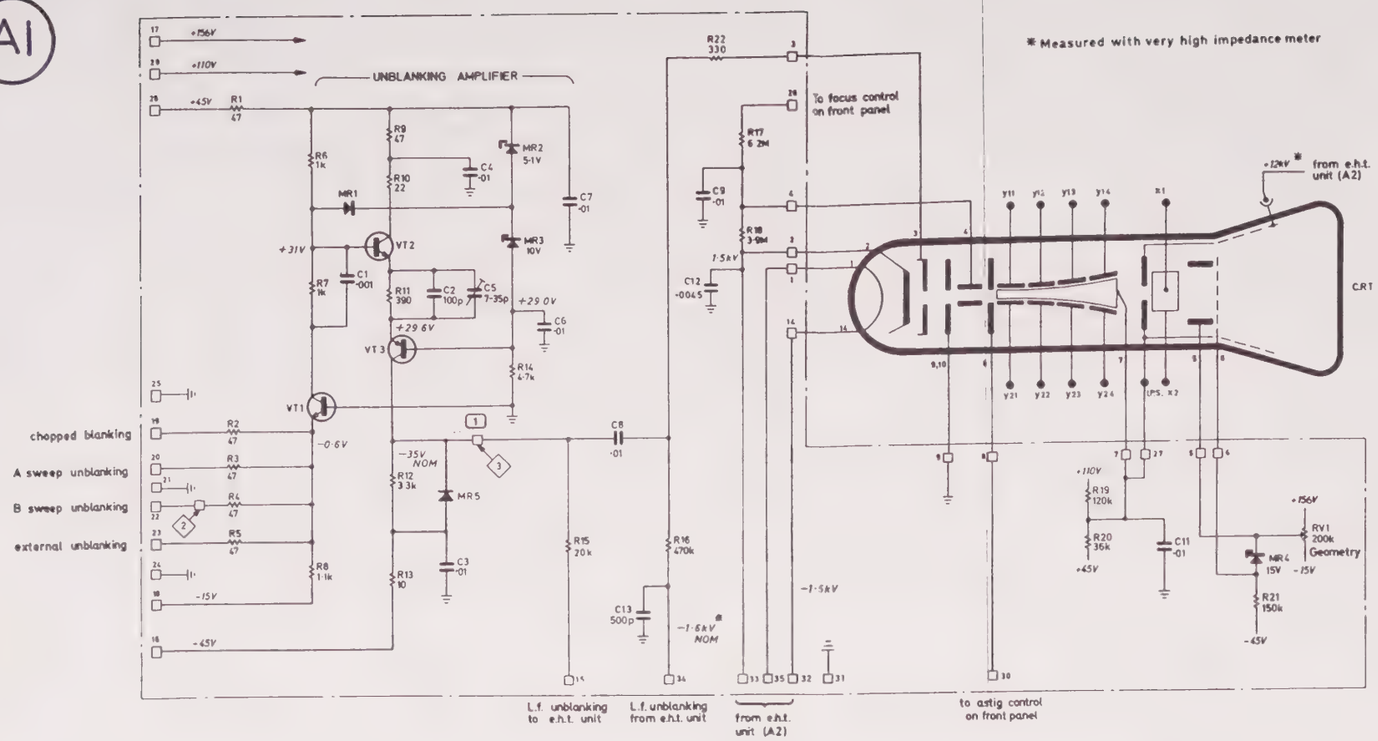
OSCILLOGRAM SUMMARY

The probe was switched to x10 for all measurements except No 5 . The monitor oscilloscope was externally triggered for measuring No's 1 and 6 and adjustment of the INTENSITY control may be required to obtain a waveform of the same amplitude as shown (i.e. 0.5 maximum amplitude). Whilst measuring waveform No 1 the probe should be earthed to pin 21 on A1 so that the circuit does not oscillate. The amplitude of waveform No 5 is dependant on the proximity of the probe tip to the p.d.a. lead. For measurement of oscillogram No 6 the oscilloscope under test was triggered from its own e.h.t. generator.

VOLTAGE CONDITIONS FOR A1, A2.

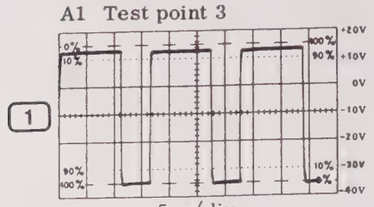
DISPLAY switch to A (sweep waiting).
DELAY switch to OFF.
SWEEP switch to NORM.
Set the INTENSITY controls (A or A & B) fully counter-clockwise.

A1

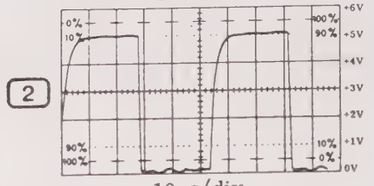


Set DISPLAY switch to B
Set DELAY switch to OFF

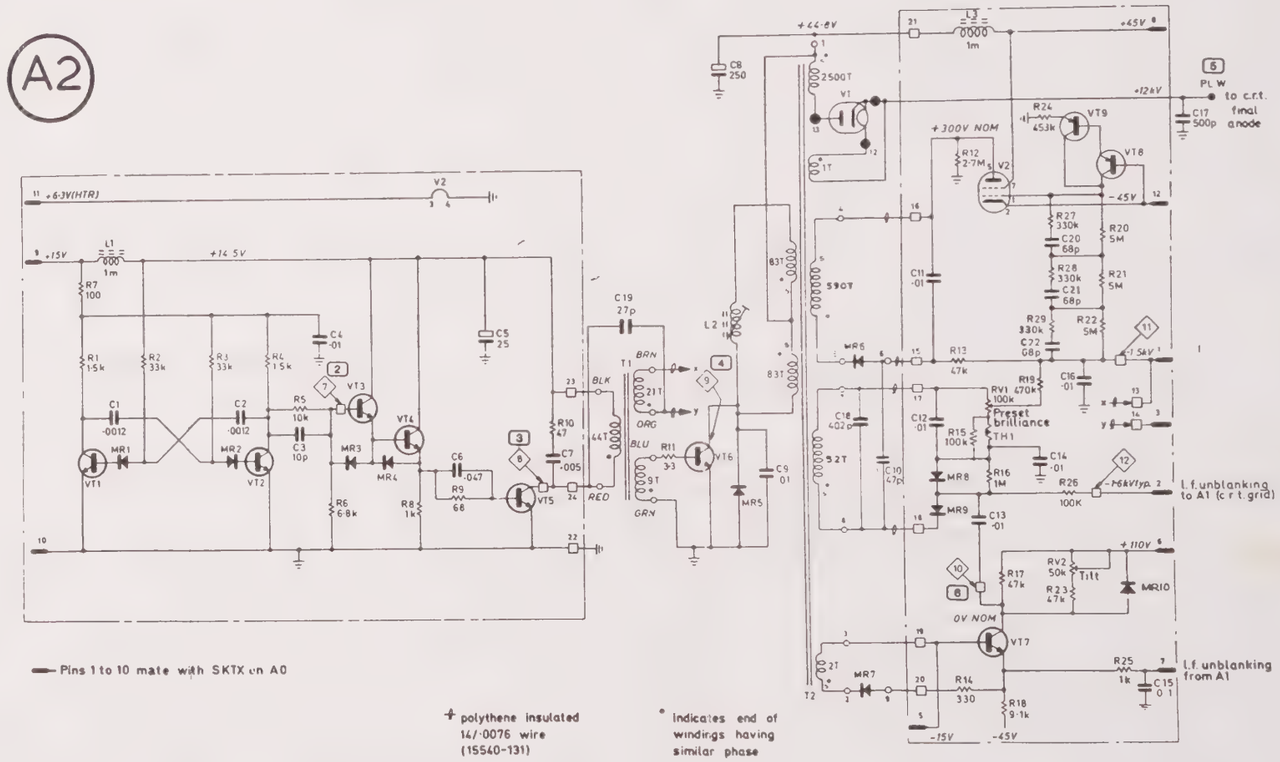
A1 Test point 3



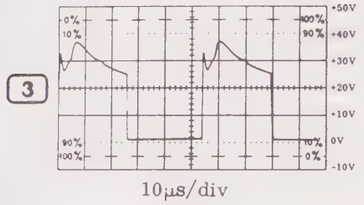
A2 Test point 7



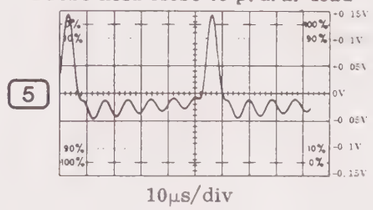
A2


Pins 1 to 10 mate with SKTX on A0
polythene insulated 14/0076 wire (15540-131)
Indicates end of windings having similar phase
Preset brilliance
Tilt
to c.r.t. final anode
l.f. unblanking to A1 (c.r.t. grid)
l.f. unblanking from A1

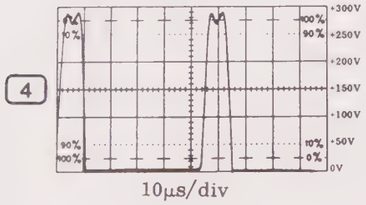
A2 Test point 8



Probe held close to p.d.a. lead



A2 Collector of VT6



A2 Test point 10

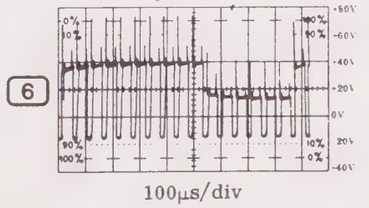


Fig. 7.2 A1 : A2 E.H.T., unblanking and c.r.t. circuits

A5 A4

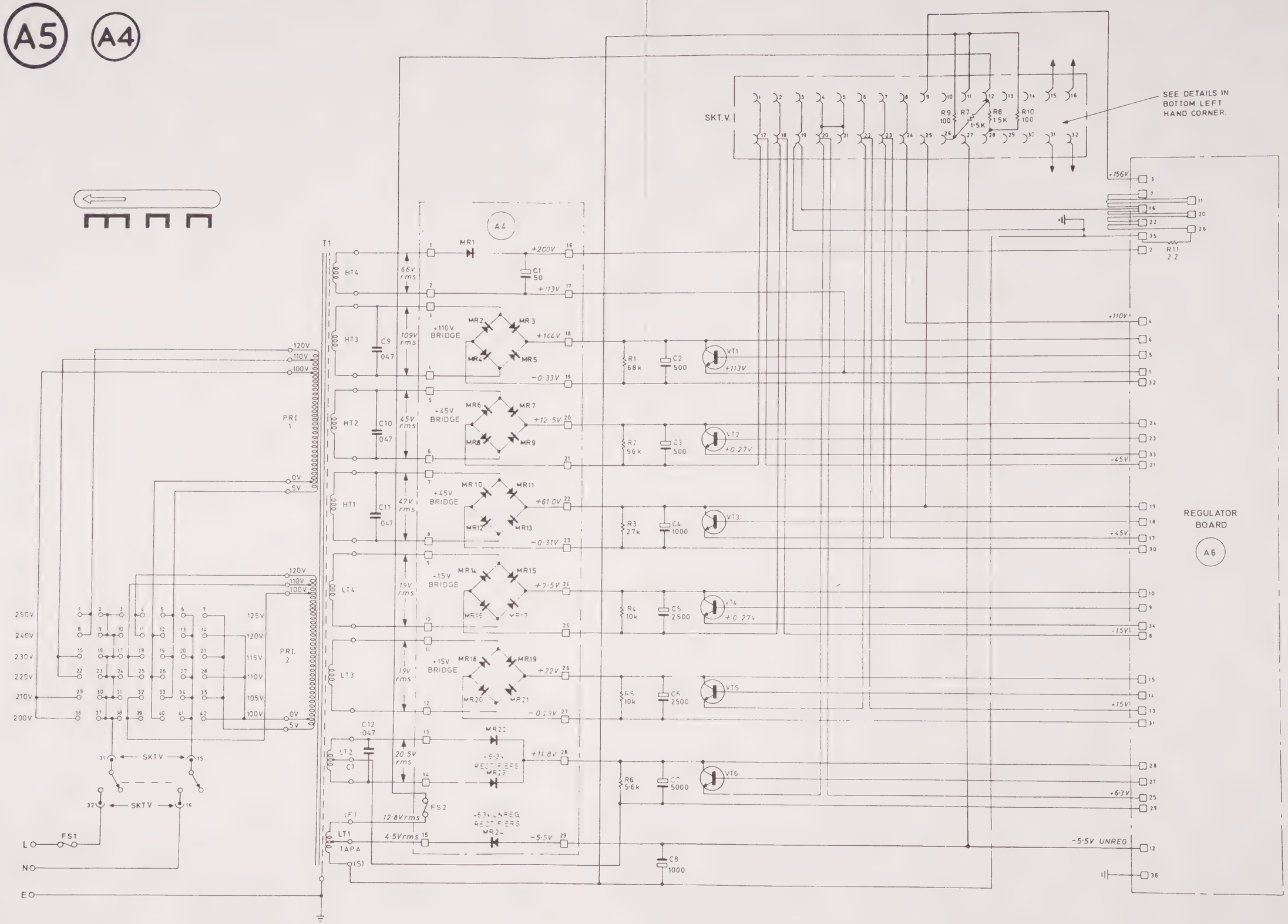
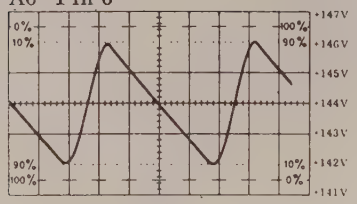


Fig. 7.3 A4 : A5 Power unit wiring

Note: Before obtaining any waveforms representative of those shown below, it is necessary to apply the correct mains voltage to the power supply as indicated on the voltage selection panel. Use a variac if necessary.

A6 Pin 6

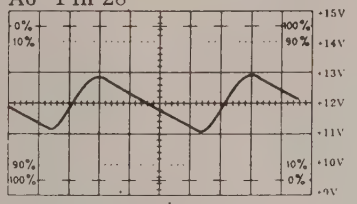
1



2ms/div

A6 Pin 28

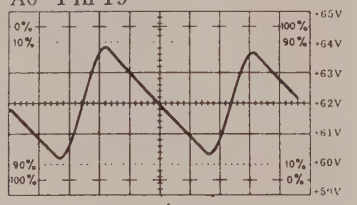
4



2ms/div

A6 Pin 19

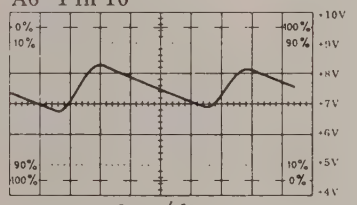
2



2ms/div

A6 Pin 10

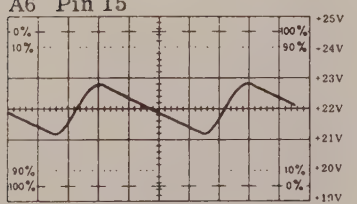
5



2ms/div

A6 Pin 15

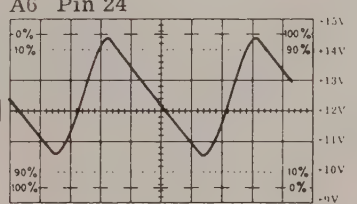
3



2ms/div

A6 Pin 24

6



2ms/div

OSCILLOGRAM SUMMARY

The probe was switched to x10 for all measurements. The monitor oscilloscope was line triggered for all measurements (i.e. triggered at supply frequency).

A6

+6·3V

+6·3V LINE RESERVOIR (SEE A5)

+15V

+15V LINE RESERVOIR (SEE A5)

+45V

+45V LINE RESERVOIR (SEE A5)

+110V

+110V LINE RESERVOIR (SEE A5)

-15V

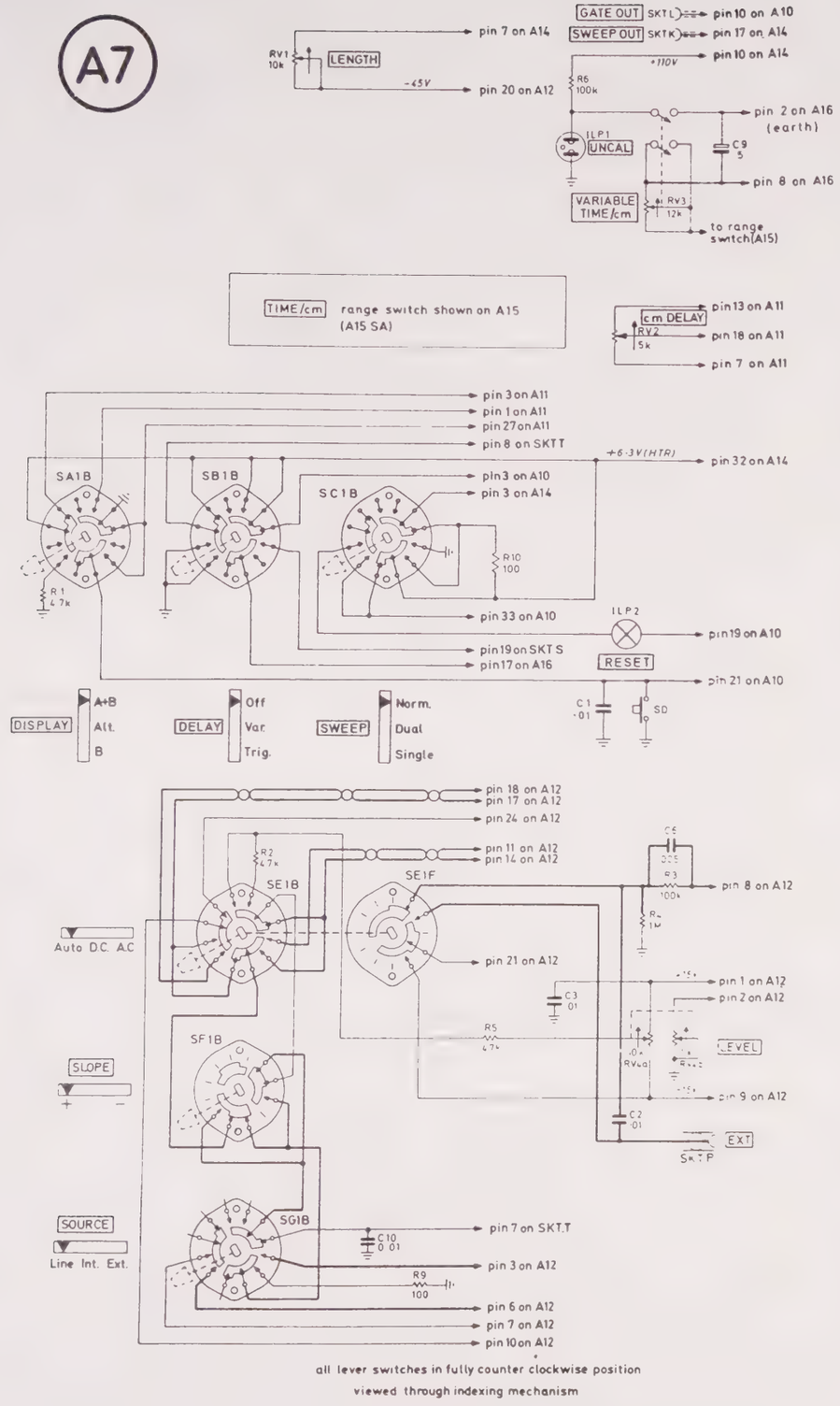
-15V LINE RESERVOIR (SEE A5)

-45V

-45V LINE RESERVOIR (SEE A5)

Fig. 7.4 A6 Regulator unit

A7



all lever switches in fully counter clockwise position

viewed through indexing mechanism

P.C.B. A14

1 ○ pin 9, A12 & pin 36, A14 (−15V)
2 ○ pin 24 on SKT S (braid to chassis)
3 ○ to SWEEP sw. on F.P.
4 ○ pin 33, A14 & pin 15, A12 (+6·3V)
5 ○ to 'retrace' R on A15
6 ○ to range 'R & C' on A15
7 ○ to LENGTH pot on F.P.
8 ○
9 ○ pin 36 on A10
10 ○ pin 14 on A11 & to F.P. (+110V)
11 ○
12 ○ earth (to chassis & braids of pins 9, 16, 17)
13 ○ pin 13 on SKT T
14 ○
15 ○
16 ○ to range 'C' on A15
17 ○ to SWEEP OUT on F.P.
18 ○ to 'range' sw. pin 1, A12, pin 28, A11 (+15V)
19 ○
20 ○
21 ○
22 ○ pin 1 on A16
23 ○ pin 26 on A12
24 ○
25 ○ earth (to chassis & braid of pin 23 only)
26 ○ pin 19 on SKT T (braid to chassis)
27 ○ pin 24 on SKT T
28 ○ to 'waiting C' on A15
29 ○
30 ○ pin 17, A11, & pin 23, A12 (+45V)
31 ○
32 ○ pin 5 SKT S, & F.P. (+6·3V HTR)
33 ○ pin 4, A14 & pin 35, A10 (+6·3V)
34 ○ pin 5, A16 & pin 20, A12 (−45V)
35 ○
36 ○ pin 1, A14 & pin 15, A11 (−15V)

P.C.B. A11

1 ○ to DISPLAY sw. on F.P.
2 ○
3 ○ to DISPLAY sw. on F.P.
4 ○ pin 15 on SKT S
5 ○ pin 19 on A16 (braid to chassis)
6 ○ pin 35, A10 & pin 30, A11 (+6·3V)
7 ○ to cm DELAY on F.P.
8 ○ earth (to chassis & braid of pin 16)
9 ○
10 ○
11 ○
12 ○
13 ○ to cm DELAY on F.P.
14 ○ pin 10, A14 & pin 8, SKT S (+110V)
15 ○ pin 36, A14 & pin 4, A10 (−15V)
16 ○ to range 'C' on A15
17 ○ pin 30 A14 & pin 7 SKT S (+45V)
18 ○ to cm DELAY on F.P.
19 ○ pin 10 on SKT S
20 ○ pin 13 on SKT S
21 ○
22 ○ pin 7, A10 & pin 17, SKT S (braid to chassis)
23 ○ pin 13 on A10 (braid to chassis)
24 ○
25 ○
26 ○ pin 20 on A16
27 ○ to DISPLAY on F.P.
28 ○ pin 13, A16 & pin 18, A14 (+15V)
29 ○
30 ○ pin 4, SKT S & pin 6, A11 (+6·3V)
31 ○
32 ○ pin 5, A16 & pin 1, SKT S (−45V)
33 ○
34 ○ pin 1 on A10
35 ○
36 ○ earth (to chassis & braid of pin 34)

X1

P.C.B. A10

1 ○ pin 34, A11 & pin 10, SKT T
2 ○
3 ○ to DELAY sw. on F.P.
4 ○ pin 15, A11 & pin 2, SKT S (−15V)
5 ○ earth (to chassis & braid of pins 1, 6, 7)
6 ○ pin 12 on SKT T
7 ○ pin 22 on A11
8 ○
9 ○ pin 13, A16 & pin 6, SKT S (+15V)
10 ○ to GATE OUT on F.P.
11 ○
12 ○
13 ○ pin 23 on A11
14 ○ pin 15 on SKT T
15 ○ pin 1 on SKT T
16 ○ pin 17 on SKT T
17 ○ pin 19, A16 & pin 11, SKT S
18 ○ earth (to chassis & braid of 10, 13, 15, 17)
19 ○ to RESET lamp on F.P.
20 ○
21 ○ to DISPLAY & RESET sw. on F.P.
22 ○
23 ○ earth (to chassis & braid of pins 34, 36)
24 ○
25 ○
26 ○
27 ○
28 ○
29 ○
30 ○
31 ○ pin 21, A16 & pin 22, SKT S
32 ○
33 ○ to SWEEP sw. on F.P.
34 ○ pin 20 on A16
35 ○ pin 6, A11 & pin 33, A14 (+6·3V)
36 ○ pin 9 on A14

P.C.B. A12

1 ○ pin 18, A14 & F.P. (+15V)
2 ○ to LEVEL pot on F.P.
3 ○ to SOURCE sw. on F.P.
4 ○ pin 4 on SKT T (braid to chassis)
5 ○ pin 5 on SKT T (braid to chassis)
6 ○ to SOURCE sw. on F.P.
7 ○ to SOURCE sw. on F.P.
8 ○ to R3 and C6
9 ○ pin 1, A14 & F.P. (−15V)
10 ○ to Auto-DC-AC sw on F.P.
11 ○ to Auto-DC-AC sw. on F.P.
12 ○
13 ○
14 ○ to Auto-DC-AC sw. on F.P.
15 ○ pin 4 on A14 (+6·3V)
16 ○ earth (to chassis)
17 ○ to Auto-DC-AC sw. on F.P.
18 ○ to Auto-DC-AC sw. on F.P.
19 ○
20 ○ pin 34, A14 & F.P. (−45V)
21 ○ to Auto-D.C-AC sw. on F.P.
22 ○
23 ○ pin 30, A14 (+45V)
24 ○ to Auto-D.C.-A.C. sw. on F.P.
25 ○ earth (braid of pin 26)
26 ○ pin 23 on A14
27 ○ earth (to chassis)

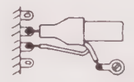
P.C.B. A16

1 ○ pin 22 on A14
2 ○ earth (to chassis, RV3 sw. & braid of pin 3)
3 ○ to 'range R' on A15
4 ○
5 ○ pin 34, A14 & pin 32, A11 (−45V)
6 ○ to SWEEP sw. on F.P. } (see A15)
7 ○ to SWEEP sw. on F.P. }
8 ○ to VARIABLE TIME/cm pot on F.P.
9 ○ }
10 ○ } to SWEEP sw. on F.P. (see A15)
11 ○ }
12 ○ }
13 ○ pin 28, A11 & pin 9, A10 (+15V)
14 ○
15 ○
16 ○
17 ○ pin 20, SKT S & DELAY sw. on F.P.
18 ○
19 ○ pin 17, A10 & pin 5, A11
20 ○ pin 34, A10 & pin 26, A11
21 ○ pin 31, on A10
22 ○ pin 21, SKT T
23 ○ earth (braid of pins 19, 20, 22)
24 ○

notes:

connections underlined are screened leads with braid earthed at board end

braids to pins 3 & 6 of SKT T to be earthed to chassis as shown in adjacent sketch.



SKT T

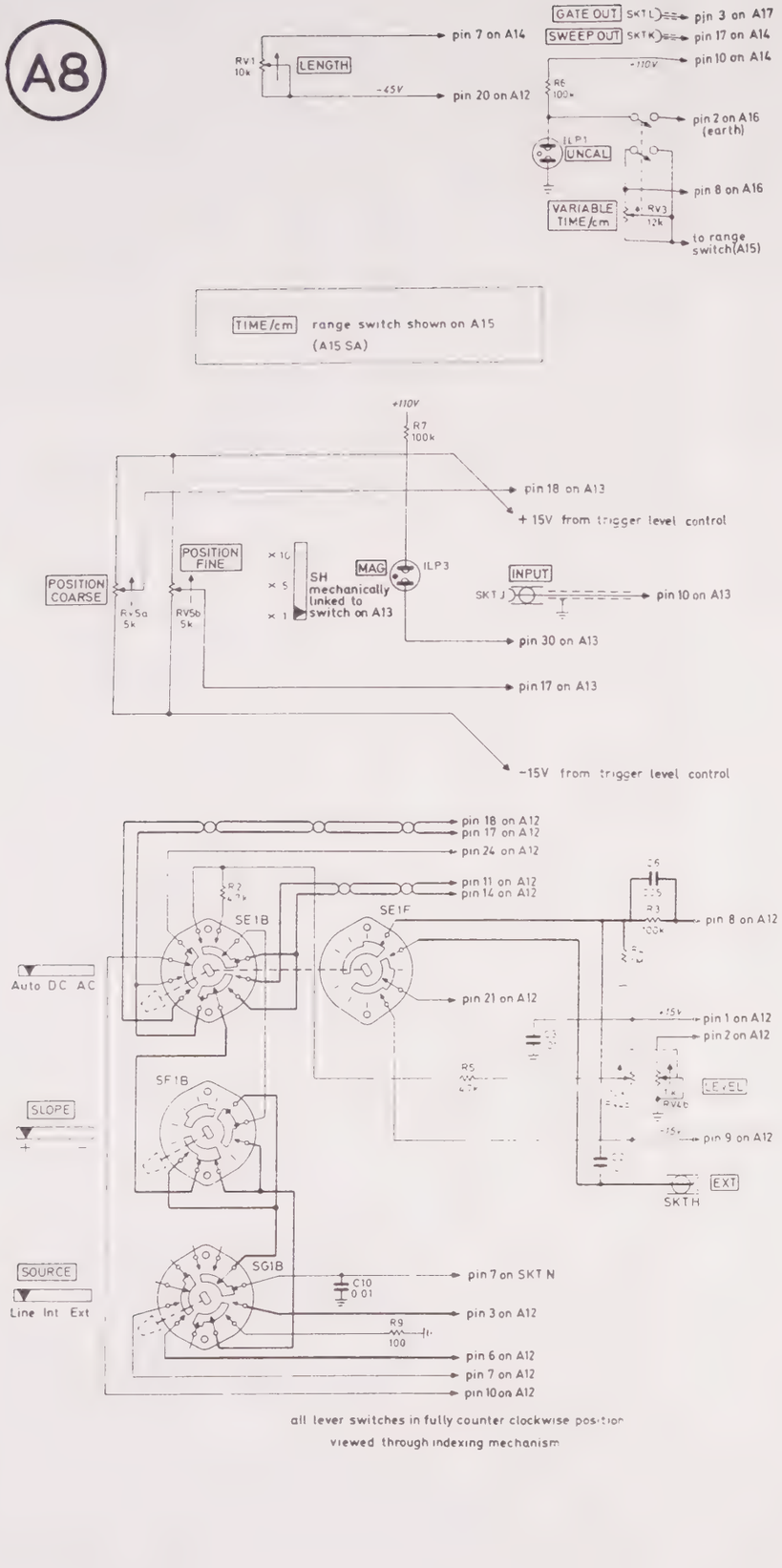
pin 15 on A10	1 13	pin 13 on A14
braid of pin 1	2 14	braid of pin 13
braid of pin 4	3 15	pin 14 on A10
pin 4 on A12	4 16	
pin 5 on A12	5 17	pin 16 on A10
braid of pin 5	6 18	braid of pin 19
to SOURCE sw. on F.P.	7 19	pin 26 on A14
to DELAY sw. on F.P.	8 20	braid of pin 21
braid of pin 10	9 21	pin 22 on A16
pin 1 on A10	10 22	
braid of pin 12	11 23	
pin 6 on A10	12 24	pin 27 on A14

SKT S

pin 32 on A11 (−45V)	1 13	pin 20 on A11 — C4 22p
pin 4 on A10 (−15V)	2 14	earth
earth	3 15	pin 4 on A11 — C5 22p
pin 30 on A11 (+6·3V)	4 16	earth
pin 32 on A14 (+6·3V HTR)	5 17	pin 22 on A11
pin 9 on A10 (+15V)	6 18	braid of pin 17
pin 17 on A11 (+45V)	7 19	to DELAY sw. on F.P.
pin 14 on A11 (+110V)	8 20	pin 17 on A16
earth	9 21	earth
pin 19 on A11	10 22	pin 31 on A10
pin 17 on A10	11 23	braid of pin 24
earth	12 24	pin 2 on A14

Fig. 7.5 A7 A sweep interconnecting diagram

A8



all lever switches in fully counter clockwise position viewed through indexing mechanism

P.C.B. (A14)

1	pin 36, A14 & pin 9, A12 (−15V)
2	
3	
4	pin 33, A14 & pin 15, A12 (+6·3V)
5	to 'retrace' R on A15
6	to 'range' R & C on A15
7	to LENGTH pot on F.P.
8	
9	pin 12 on A17
10	pin 21 on A17 & to F.P. (+110V)
11	
12	earth (to chass. & braids of pins 9, 16, 17)
13	pin 34 on A17
14	
15	
16	to range 'C' on F.P.
17	to SWEEP OUT on F.P.
18	to range sw, pin 1, A12 & pin 4, A17 (+15V)
19	pin 24 on SKT M (braid to chassis)
20	pin 10 on SKT N (braid to chassis)
21	pin 8 on SKT N
22	pin 1 on A16
23	pin 26 on A12
24	
25	earth (to chassis & braid of pin 23 only)
26	pin 13 on SKT M (braid to chassis)
27	pin 24 on SKT N
28	to waiting 'C' on A15
29	
30	pin 35, A13 & pin 23, A12 (+45V)
31	
32	pin 5, SKT M (+6·3V HTR)
33	pin 4, A14 & pin 17, A17 (+6·3V)
34	pin 5, A16, & pin 20, A12 (−45V)
35	
36	pin 1, A14 & pin 33, A13 (−15V)

P.C.B. (A17)

1	
2	earth (to chassis)
3	to GATE OUT on F.P.
4	pin 36 on A13 & pin 18 on A14 (+15V)
5	
6	earth (braids of pins 3 & 12)
7	
8	
9	
10	
11	
12	
13	pin 9 on A14
14	
15	pin 15 on SKT N
16	
17	
18	pin 32, A13 & pin 33, A14 (+6·3V)
19	
20	pin 17 on SKT M (braid to chassis)
21	pin 3 on A13 & pin 1, SKT M (−45V)
22	pin 8, SKT M & pin 10, A14 (+110V)
23	pin 6 on A13 (braid to chassis)
24	
25	
26	pin 13 on SKT N (braid to chassis)
27	pin 11 on SKT M
28	
29	
30	pin 2, A13 & pin 2, SKT M (−15V)
31	
32	pin 19 on A16
33	
34	pin 13 on A14
35	earth (to chassis & braid of pin 34)
36	pin 1 on SKT N (braid to chassis)

P.C.B. (A13)

1	pin 4, SKT M & pin 32, A13 (+6·3V)
2	pin 33, A13 & pin 30, A17 (−15V)
3	pin 34, A13 & pin 20, A17 (−45V)
4	
5	
6	pin 22 on A17
7	
8	earth (braids of pins 6 & 10)
9	
10	to INPUT (SKT J) on F.P.
11	
12	
13	
14	
15	
16	earth (to chassis)
17	to FINE POSITION pot on F.P.
18	to COARSE POSITION pot on F.P.
19	
20	
21	
22	
23	
24	
25	
26	pin 19 on SKT N
27	earth (braids of pins 26 & 28)
28	pin 20 on SKT N
29	pin 23 on SKT N
30	to MAG lamp on F.P.
31	to pin 22 on SKT N
32	pin 17, A17 & pin 1, A13 (+6·3V)
33	pin 36, A14 & pin 2, A13 (−15V)
34	pin 3, A13 & pin 5, A16 (−45V)
35	pin 7, SKT M & pin 30, A14 (+45V)
36	pin 4, A17 & pin 13, A16 (+15V)

P.C.B. (A12)

1	pin 18, A14, & F.P. (+15V)
2	to LEVEL pot on F.P.
3	to SOURCE sw. on F.P.
4	pin 4 SKT N (braid to chassis)
5	pin 5 SKT N (braid to chassis)
6	to SOURCE sw. on F.P.
7	to SOURCE sw. on F.P.
8	to R3 and C6
9	pin 1, A14 & F.P. (−15V)
10	to Auto−DC−AC sw. on F.P.
11	to Auto−DC−AC sw. on F.P.
12	
13	
14	to Auto−DC−AC sw. on F.P.
15	pin 4 on A14 (+6·3V)
16	earth (to chassis)
17	to Auto−DC−AC sw. on F.P.
18	to Auto−DC−AC sw. on F.P.
19	
20	pin 34, A14 & F.P. (−45V)
21	to Auto−DC−AC sw. on F.P.
22	
23	pin 30, A14
24	to Auto−DC−AC sw. on F.P.
25	earth (braid of pin 26)
26	pin 23 on A14
27	earth (to chassis)

P.C.B. (A16)

1	pin 22 on A14
2	earth (to chassis RV3 sw. & braid of pin 3)
3	to range 'R' on A15
4	
5	pin 34, A14 & pin 34, A13 (−45V)
6	to SWEEP sw. on F.P. (see A15)
7	to SWEEP sw on F.P.
8	to VARIABLE TIME/cm pot on F.P.
9	
10	to SWEEP sw. on F.P. (see A15)
11	
12	
13	pin 36, A13 & pin 6, SKT M (+15V)
14	
15	
16	
17	pin 20 on SKT M
18	pin 15 on SKT M
19	pin 10, SKT M & pin 32, A17
20	pin 12 on SKT N
21	pin 22 on SKT M
22	pin 19 on SKT M
23	earth (to chassis & braids of pins 18 & 20)
24	

SKT N

pin 36 on A17	1	13	pin 25 on A17
braid of pin 1	2	14	braid of pin 13
braid of pin 4	3	15	pin 14 on A17
pin 4 on A12	4	16	
pin 5 on A12	5	17	
braid of pin 5	6	18	braid of pin 19
to SOURCE sw. on F.P.	7	19	pin 26 on A13
pin 21 on A14	8	20	pin 28 on A13
braid of pin 10	9	21	braid of pin 20
pin 20 on A14	10	22	pin 31 on A13
braid of pin 12	11	23	pin 29 on A13
pin 20 on A16	12	24	pin 27 on A14

SKT M

pin 20 on A17 (−45V)	1	13	pin 26 on A14
pin 30 on A17 (−15V)	2	14	braid of pin 13
earth	3	15	pin 18 on A16
pin 1 on A13 (+6·3V)	4	16	braid of pin 15
pin 32 on A14 (+6·3V HTR)	5	17	pin 19 on A17
pin 13 on A16 (+15V)	6	18	braid of pin 17
pin 35 on A13 (+45V)	7	19	pin 22 on A16
pin 21 on A17 (+110V)	8	20	pin 17 on A16
earth	9	21	earth
pin 19 on A16	10	22	pin 21 on A16
pin 27 on A17	11	23	braid of pin 24
earth	12	24	pin 19 on A14

notes

connections underlined are screened leads with braid earthed at board end

braids to pins 3 & 6 of SKT N to be earthed to chassis as shown in adjacent sketch.

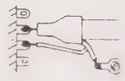
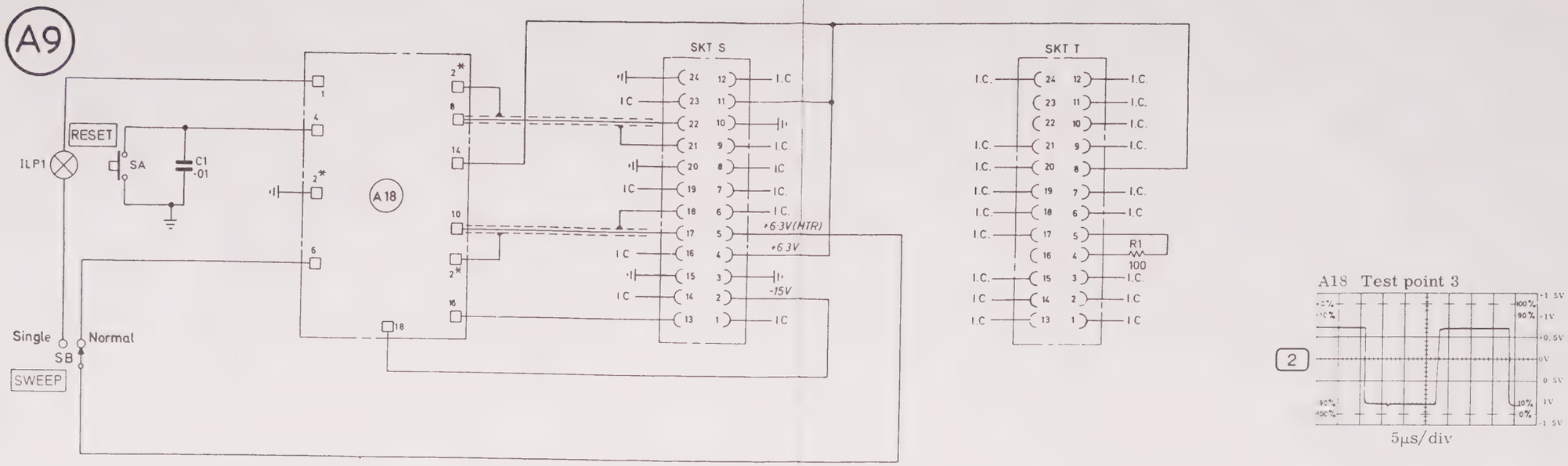


Fig. 7.6 A3 B sweep interconnecting diagram



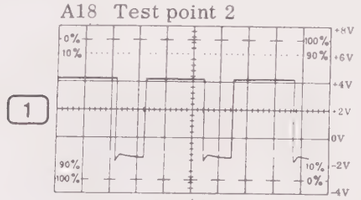
Note ; I.C. denotes that the corresponding contact of the plug in the main frame has a connection to other circuits

A18 Test point 3

OSCILLOGRAM SUMMARY

The probe was switched to x10 and the monitor oscilloscope externally triggered for each measurement.

A18 Test point 2



VOLTAGE CONDITIONS FOR A18

SWEEP switch to NORM (sweep waiting).

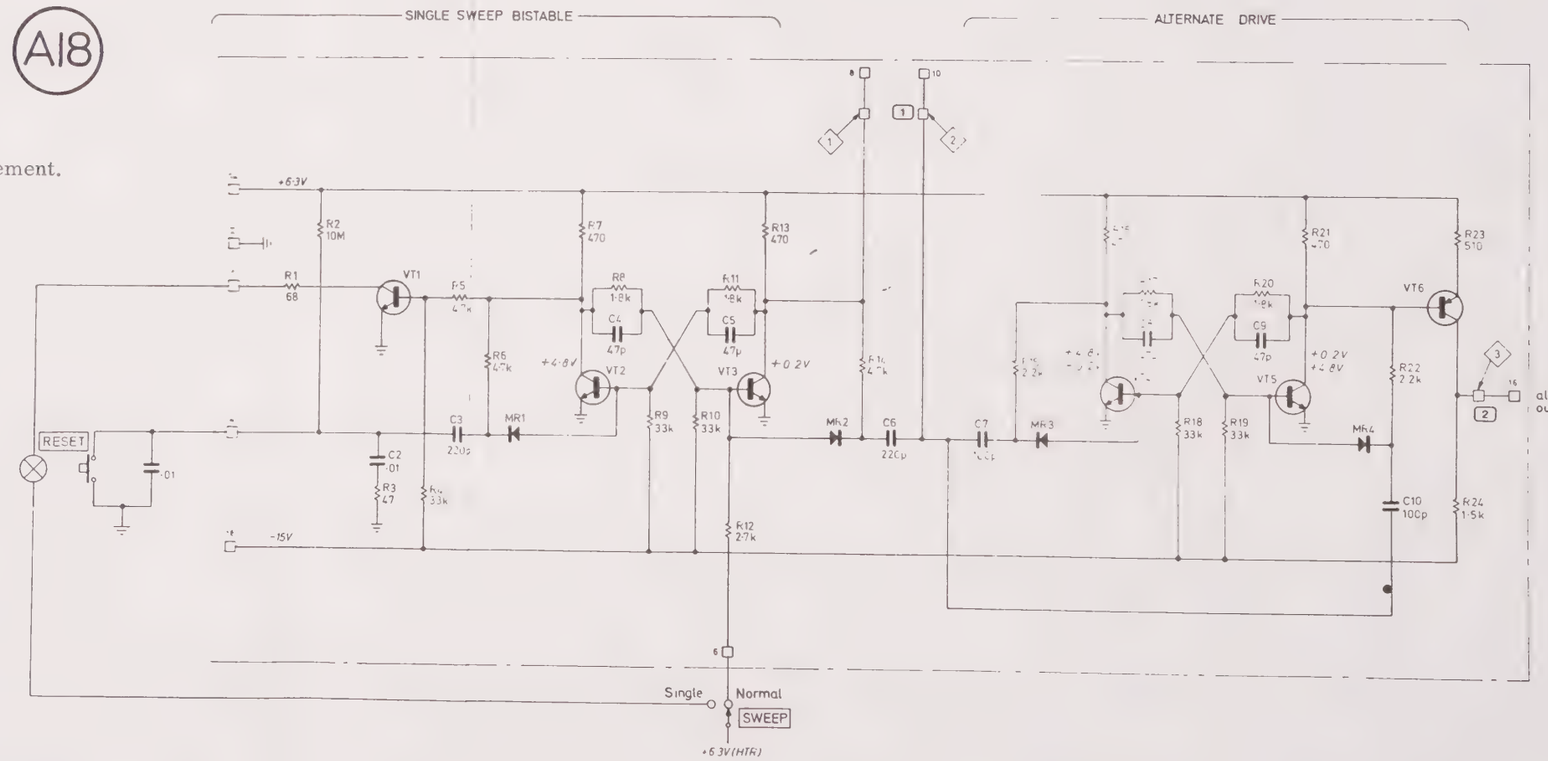
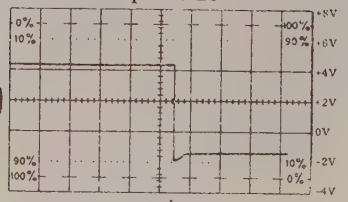


Fig. 7.7 A9 : A18 Single sweep unit interconnection and circuit diagram

A10 Test point 28

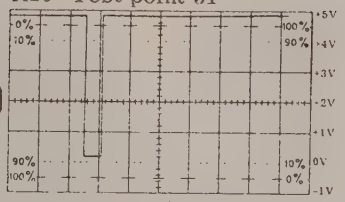
1



20μs/div

A10 Test point 31

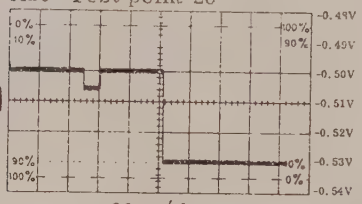
3



20μs/div

A10 Test point 26

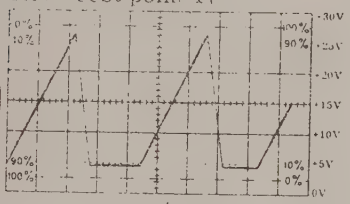
2



20μs/div

A17 Test point 17

4



30μs/div

OSCILLOGRAM SUMMARY

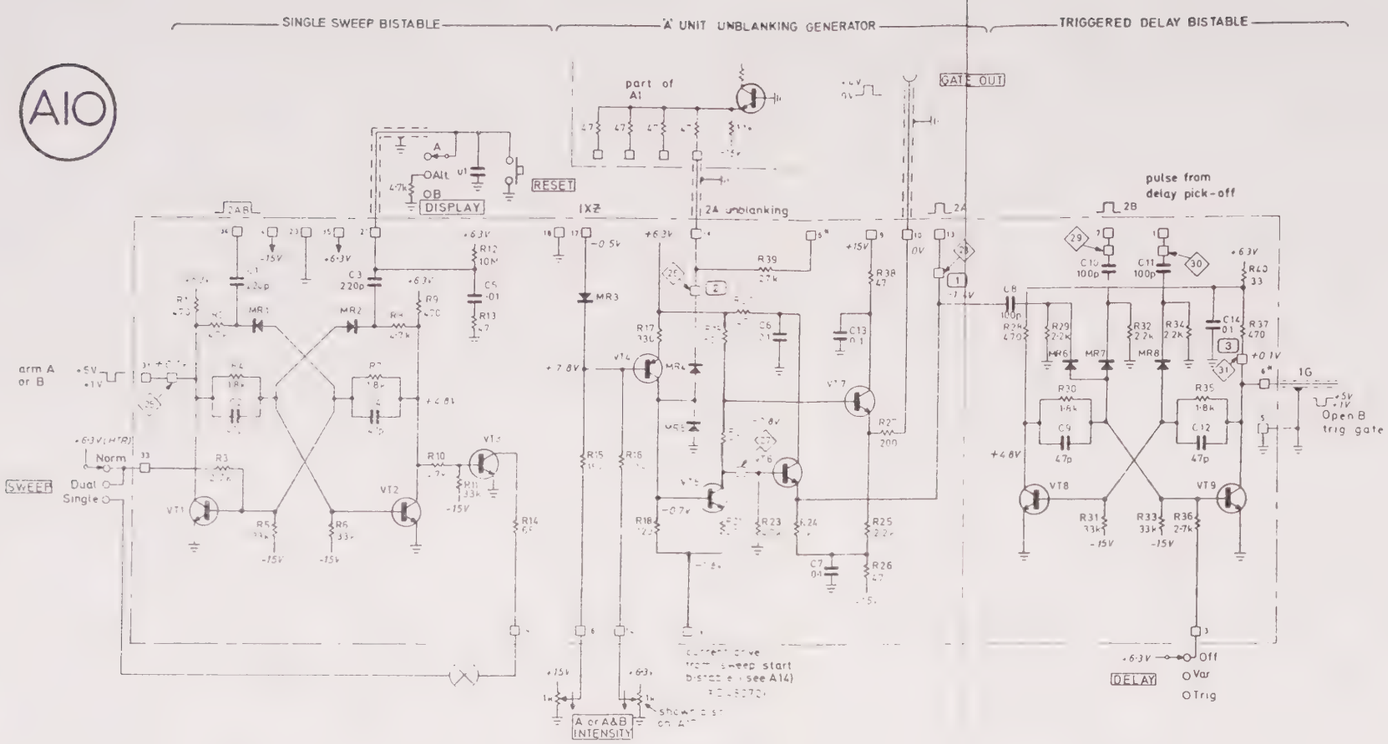
The probe was switched to x10 for all measurements except No's 2 and 10. The monitor oscilloscope was externally triggered for all measurements. The plug-in was removed and operated on extension leads for the first three oscillograms. When measuring waveform No 10 adjustment of the INTENSITY control may be required to obtain a waveform of the same amplitude as shown (i.e. 0.5 maximum amplitude).

VOLTAGE CONDITIONS FOR A10.

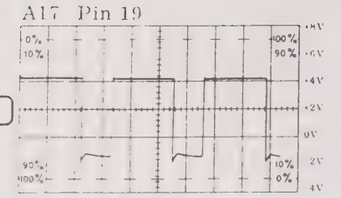
DISPLAY switch to A (sweep waiting).
DELAY switch to OFF.
SWEEP switch to NORM.
Set the INTENSITY controls (A or A & B) fully counter-clockwise.

VOLTAGE CONDITIONS FOR A17

DISPLAY switch to A (sweep waiting).
DELAY switch to OFF.
SWEEP switch to NORM.
INTENSITY controls (A and A & B) fully counter-clockwise.

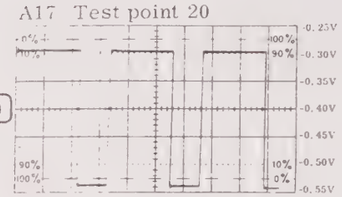


A17 Pin 19



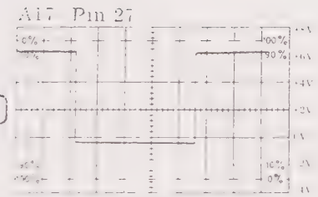
5μs/div

A17 Test point 20



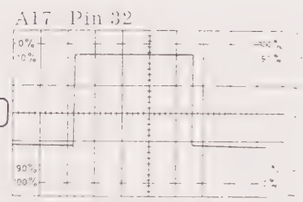
5μs/div

A17 Pin 27



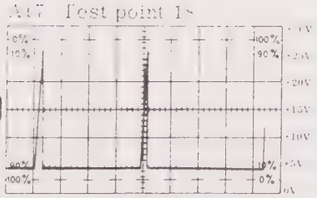
50μs/div

A17 Pin 32



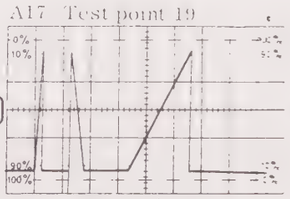
50μs/div

A17 Test point 18



50μs/div

A17 Test point 19



50μs/div

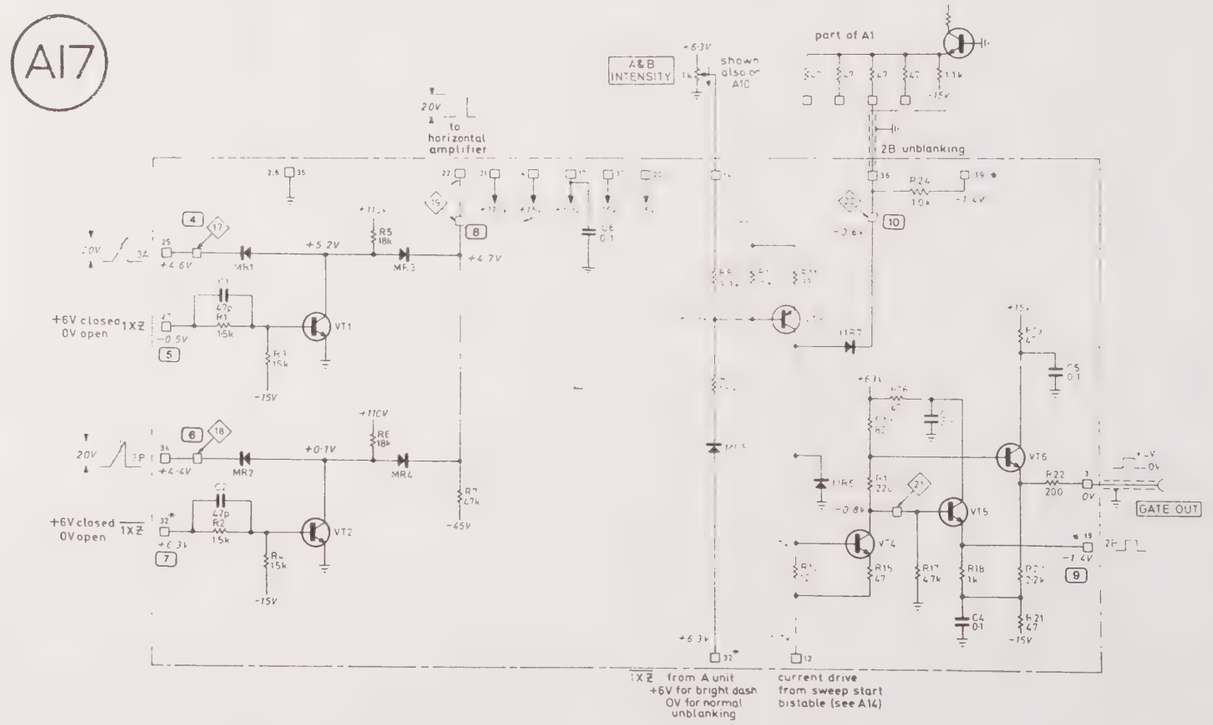
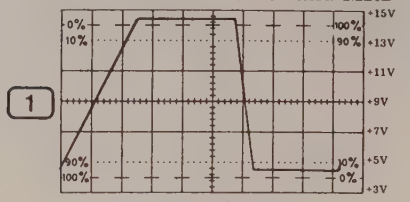


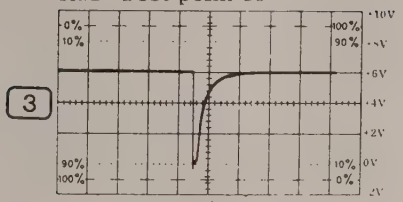
Fig. 7.8 A10 : A17 A and B unblanking; A sweep single sweep circuit and B sweep high level sweep gates

A11 Junction of MR1 and MR2



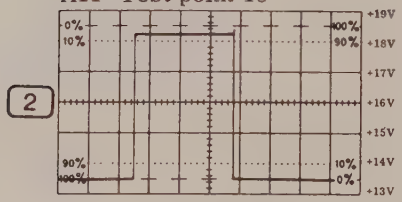
20μs/div

A11 Test point 19



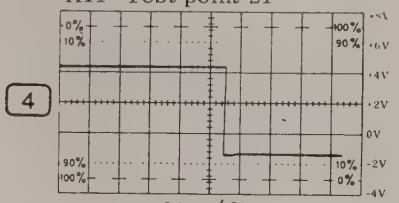
1μs/div

A11 Test point 18



20μs/div

DISPLAY switch to ALT
A11 Test point 21



20μs/div

OSCILLOGRAM SUMMARY

The probe was switched to x10 for all measurements except No's 6 and 8. The monitor oscilloscope was externally triggered for all measurements except No 7. The polarity of waveforms No 5 and 8 may reverse depending on the triggering phase.

VOLTAGE CONDITIONS FOR A11

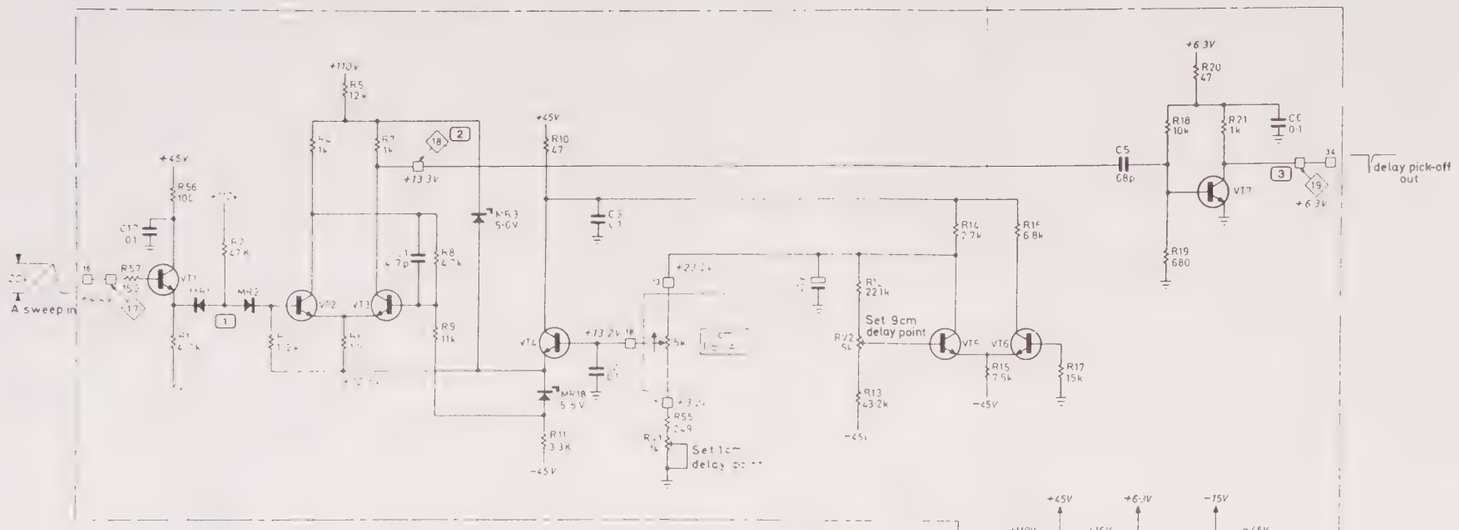
DISPLAY switch to A (sweep waiting).
DELAY switch to OFF.
SWEEP switch to NORM.
CM DELAY control to 5.00.

A11

DELAY PICK-OFF SCHMIDT

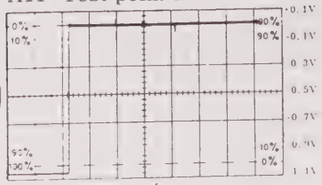
VOLTAGE COMPARATOR

DELAY PICK-OFF BUFFER



DISPLAY switch to ALT
A11 Test point 24

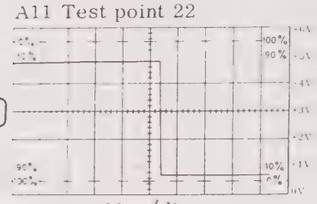
8



50μs/div

A11 Test point 22

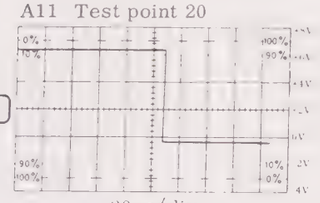
9



20μs/div

DISPLAY switch to ALT
A11 Test point 20

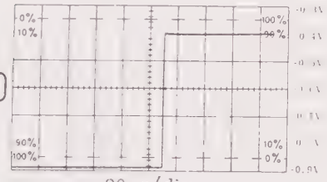
5



20μs/div

DISPLAY switch to ALT
A11 Test point 23

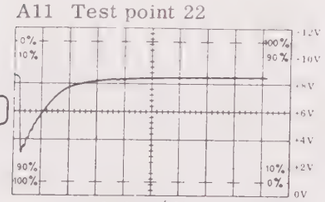
6



20μs/div

DISPLAY switch to ALT
A11 Test point 22

7



0.1μs/div

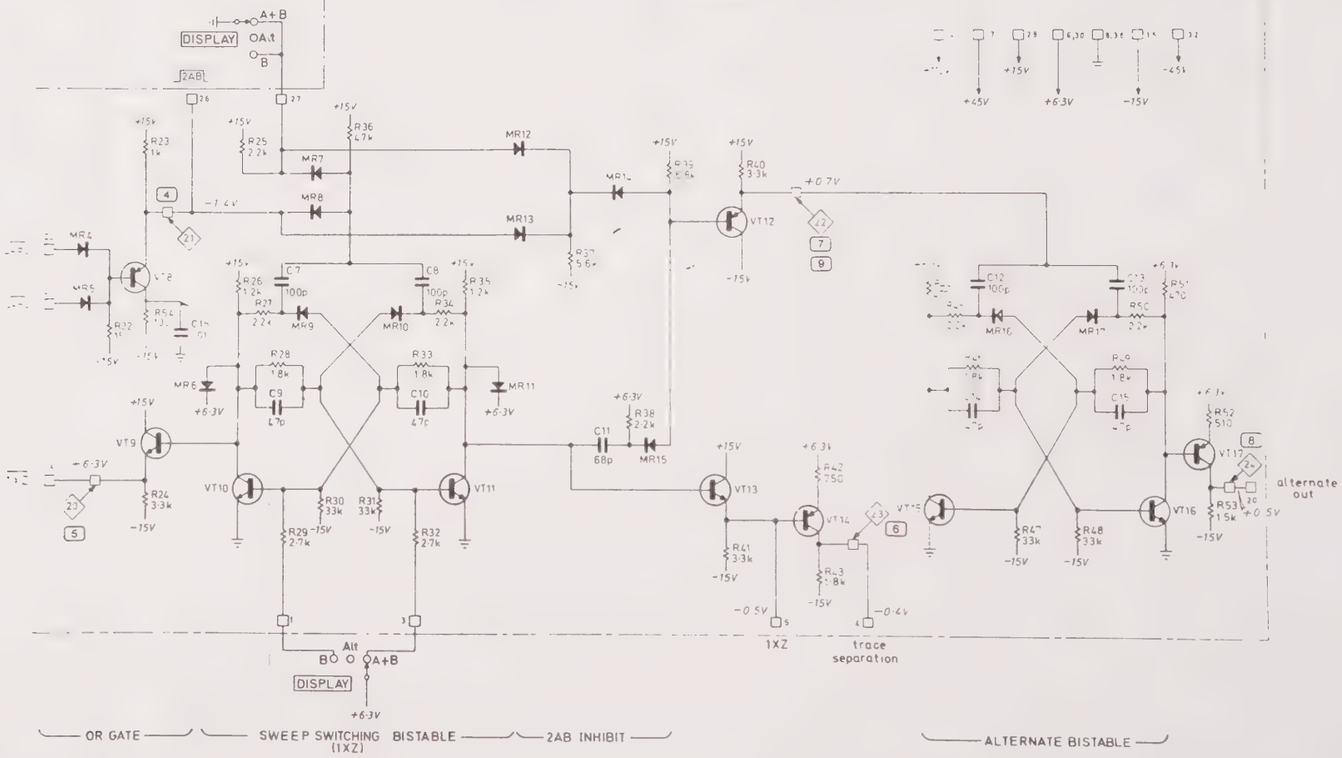
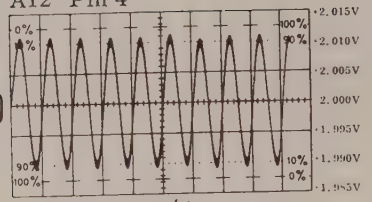


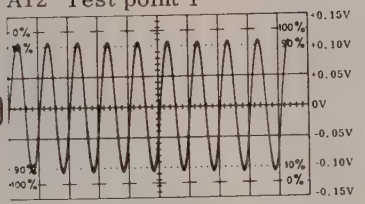
Fig. 7.9 A11 Delay pick-off; switching and alternative bistables

A12 Pin 4



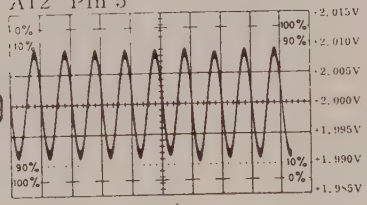
1

A12 Test point 1



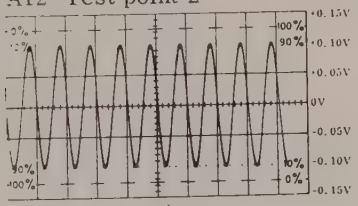
3

A12 Pin 5



2

A12 Test point 2



4

OSCILLOGRAM SUMMARY

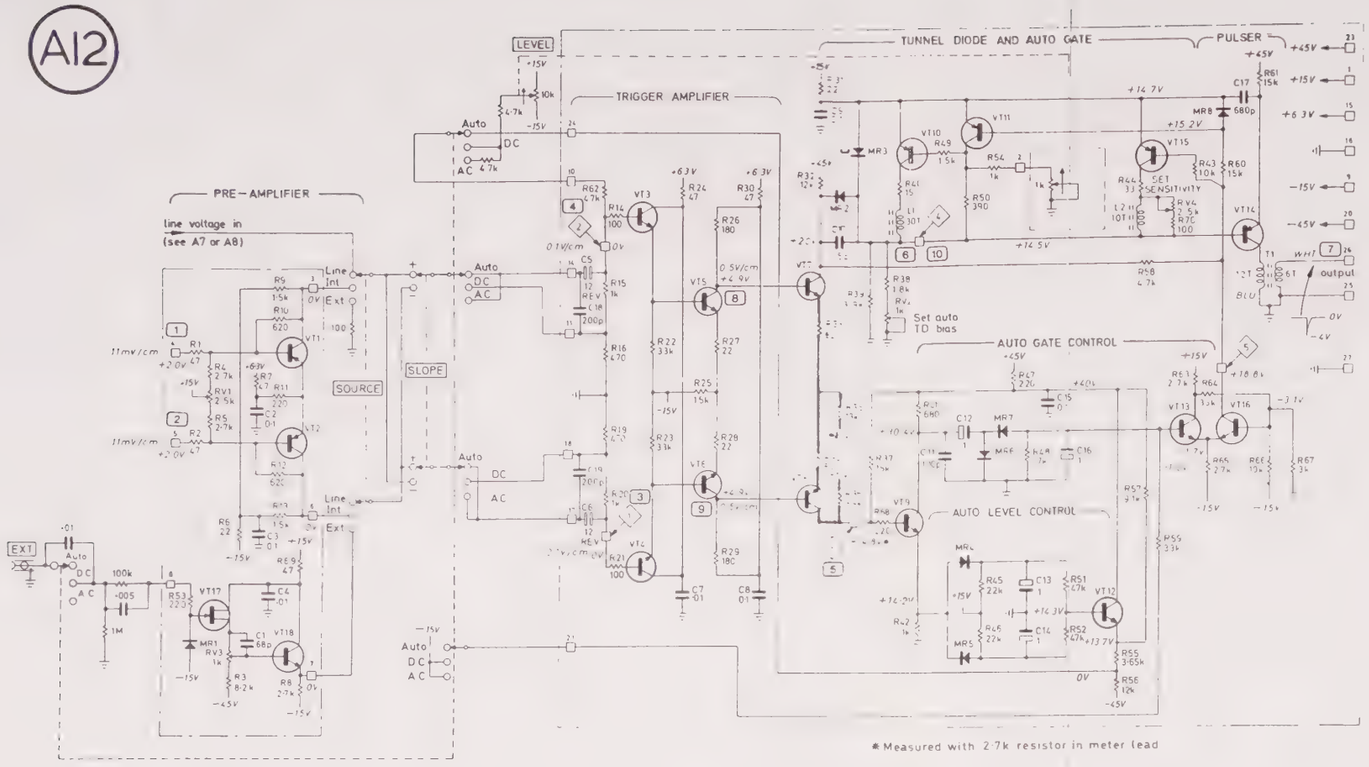
Set the dual trace unit TRIGGER switch to CH1 and apply a 100kHz sine wave to the CH1 input. Adjust the channel 1 VOLTS/CM control to give 2cm vertical deflection. For oscillogram No 10 . remove the 100kHz signal and apply a 50MHz sine wave with sufficient amplitude for 5cm of deflection.

The probe was switched to x10 for the measurement of No's 5 , 7 and 10 . The plug-in was removed and operated on extension leads and the monitor oscilloscope was externally triggered for all measurements.

VOLTAGE CONDITIONS FOR A12

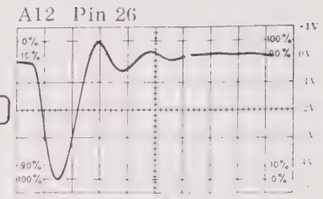
DISPLAY switch to A (sweep waiting or running).
DELAY switch to OFF.
SWEEP switch to NORM.
TRIGGER switch to AUTO.
SLOPE switch to +.
SOURCE switch to INT.
VOLTS/CM switches to 1V/cm.
VARIABLE VOLTS/CM controls to CAL.
DISPLAY switch to CH1.
TRIGGER switch to CH1.
Centre the CH1 and CH2 traces using the VERTICAL POSITION controls, then select CH1.

A12



A12 Pin 26

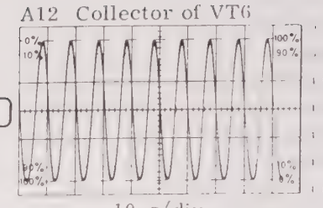
7



10ns/div

A12 Collector of VT6

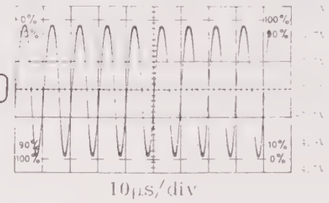
9



10μs/div

A12 Collector of VT5

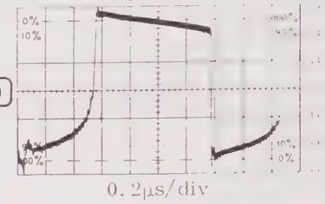
8



10μs/div

A12 Test point 4

10

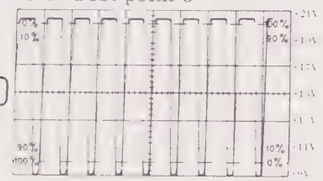


0.2μs/div

A15

A12 Test point 3

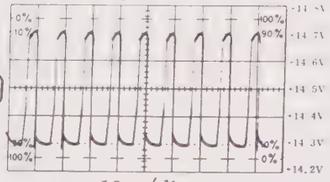
5



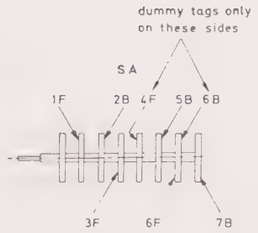
10μs/div

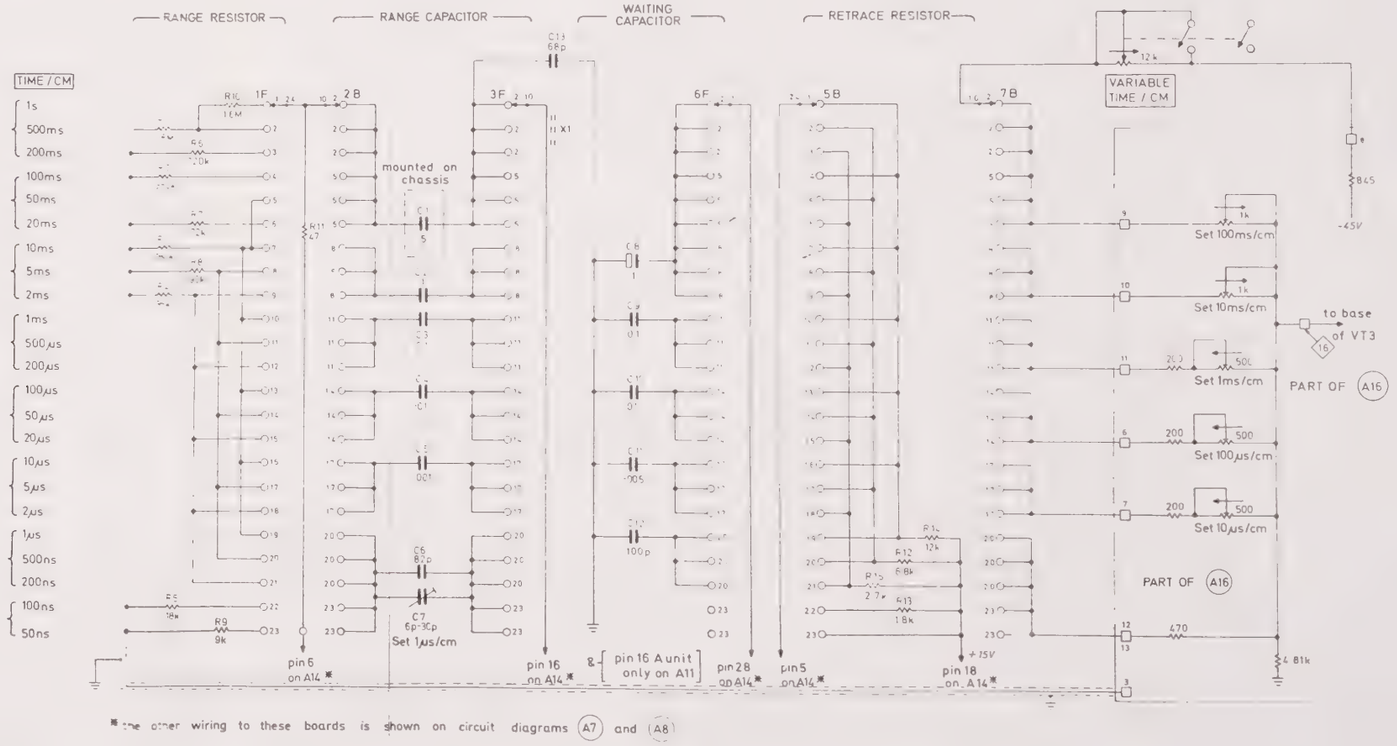
A12 Test point 4

6



10μs/div





* the other wiring to these boards is shown on circuit diagrams (A7) and (A8)

Fig. 7.10 A12 : A15 Trigger circuits and TIME CM switch

OSCILLOGRAM SUMMARY

The probe was switched to x10 for all measurements and the plug-in removed and operated on extension leads. The monitor oscilloscope was externally triggered. On the test oscilloscope the start of the displayed trace was positioned on the first vertical graticule line and the trace length adjusted for 10cm for all measurements.

VOLTAGE CONDITIONS FOR A13

DISPLAY switch to A (sweep waiting).
DELAY switch to OFF.
SWEEP switch to NORM.
Horizontal MAG switch to x1.
Set the spot on the left-hand side of the screen.

VOLTAGE CONDITIONS FOR A19

DISPLAY switch to A (sweep waiting).
DELAY switch to OFF.
SWEEP switch to NORM.
Ensure that the correct mains voltage is used for the mains tapping panel position selected.

A13

FINE
POSITION
INPUT
1V/cm
sweep in
20V
2V/cm
MAG (SH on A8)
TRACE FINDER
current drive to output stage (see A0 via A8)
0·10V/cm (NOM)
0·56V/cm
Set ×5
Set ×10
Set bal
Set gain

A19

+60V nom: from reservoir
POWER ON
SUPPLY LIGHT CONTROL
CALIBRATOR
Set cal.
CALIBRATOR 3V: 6mA

A13 Test point 22

1

50μs/div

A13 Test point 23

2

50μs/div

A13 Test point 24

3

50μs/div

Horizontal amplifier MAG switch to x5

A13 Test point 24

4

50μs/div

Horizontal amplifier MAG switch to x10

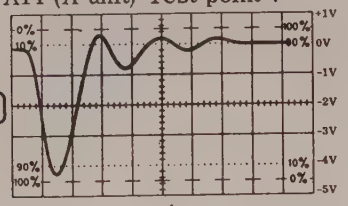
A13 Test point 24

5

50μs/div

Fig. 7.11 A13 : A19 Horizontal amplifier, calibrator and supply light control circuits

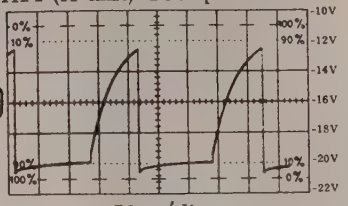
Set SWEEP switch to DUAL
A14 (A unit) Test point 7



1

10ns/div

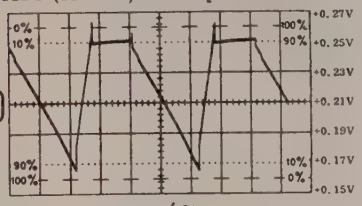
Set SWEEP switch to DUAL
A14 (A unit) Test point 9



4

50µs/div

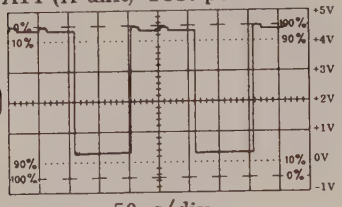
Set SWEEP switch to DUAL
A14 (A unit) Test point 12



7

50µs/div

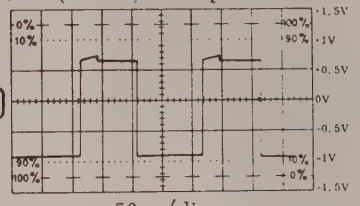
Set SWEEP switch to DUAL
A14 (A unit) Test point 8



2

50µs/div

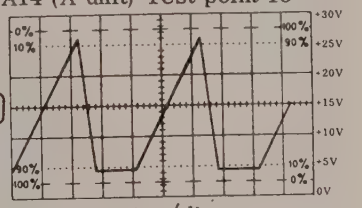
Set SWEEP switch to DUAL
A14 (A unit) Test point 10



5

50µs/div

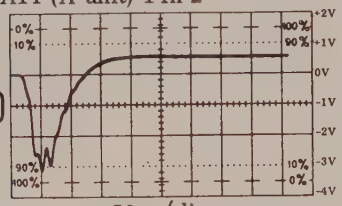
Set SWEEP switch to DUAL
A14 (A unit) Test point 13



8

50µs/div

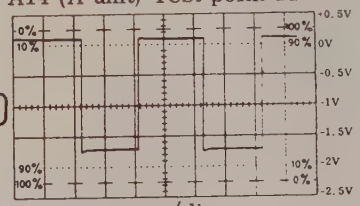
Set SWEEP switch to DUAL
A14 (A unit) Pin 2



3

50ns/div

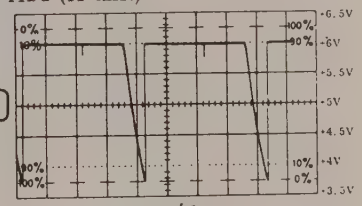
Set SWEEP switch to DUAL
A14 (A unit) Test point 11



6

50µs/div

Set SWEEP switch to DUAL
A14 (A unit) Pin 26



9

50µs/div

OSCILLOGRAM SUMMARY

The probe was switched to x10 for all measurements except No 7. The monitor oscilloscope was externally triggered for all measurements except No 12, when the oscilloscope was internally triggered.

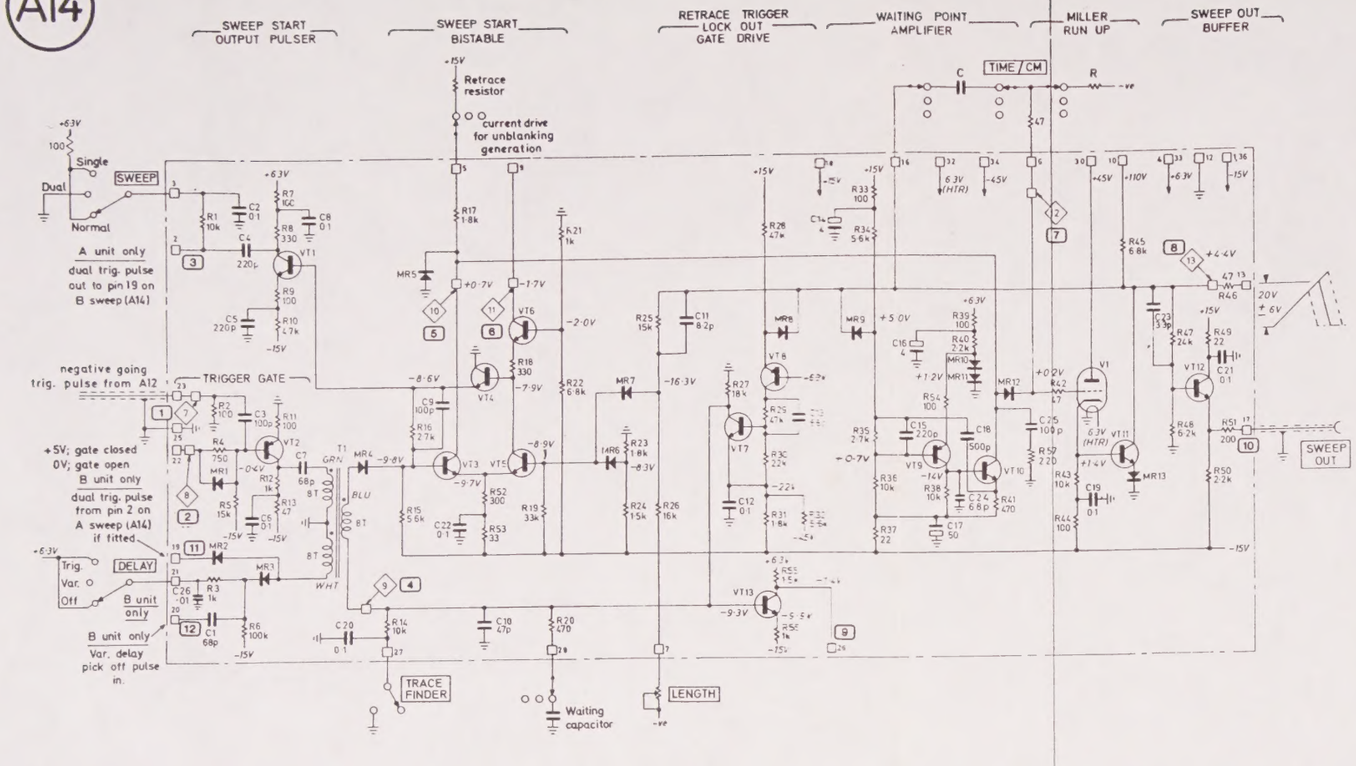
VOLTAGE CONDITIONS FOR A14

SOURCE switch to EXT (no signal connected, sweep waiting).
TIME/CM switch to 1 ms/cm.
TRACE LENGTH previously set to give 10 cm of trace on 1 ms/cm range.

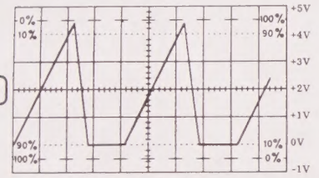
VOLTAGE CONDITIONS FOR A16

DISPLAY switch to A (sweep waiting).
DELAY switch to OFF.
SWEEP switch to NORM.
VARIABLE TIME/CM to CAL (fully clockwise).

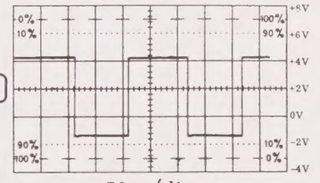
A14



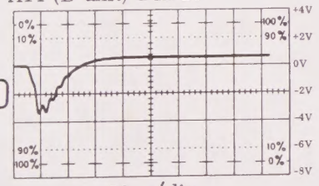
Set SWEEP switch to DUAL
A14 (A unit) Pin 17



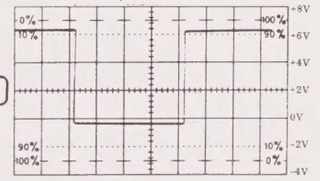
A16 (A unit) Pin 20



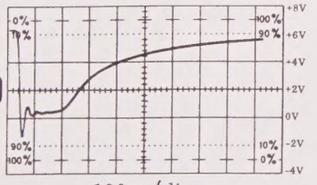
Set SWEEP switch to DUAL
A14 (B unit) Pin 19



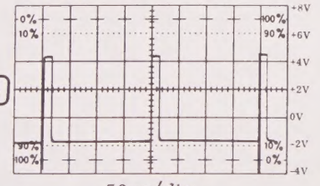
Set DISPLAY switch to ALT
A16 (A unit) Pin 19



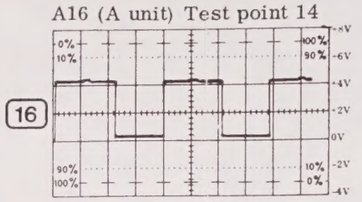
Set SWEEP switch to DUAL
A14 (B unit) Pin 20



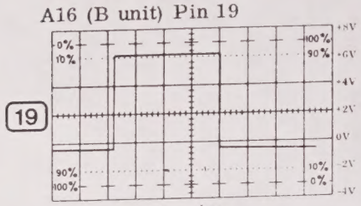
A16 (A unit) Pin 22



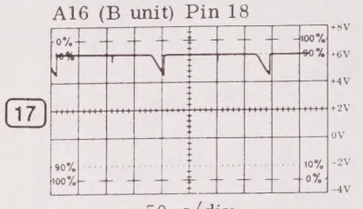
A16 (A unit) Test point 14



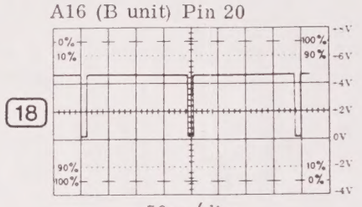
Set DISPLAY switch to ALT
A16 (B unit) Pin 19



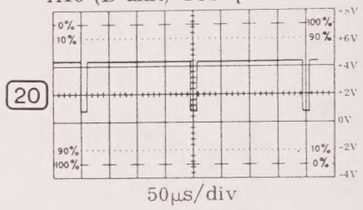
A16 (B unit) Pin 18



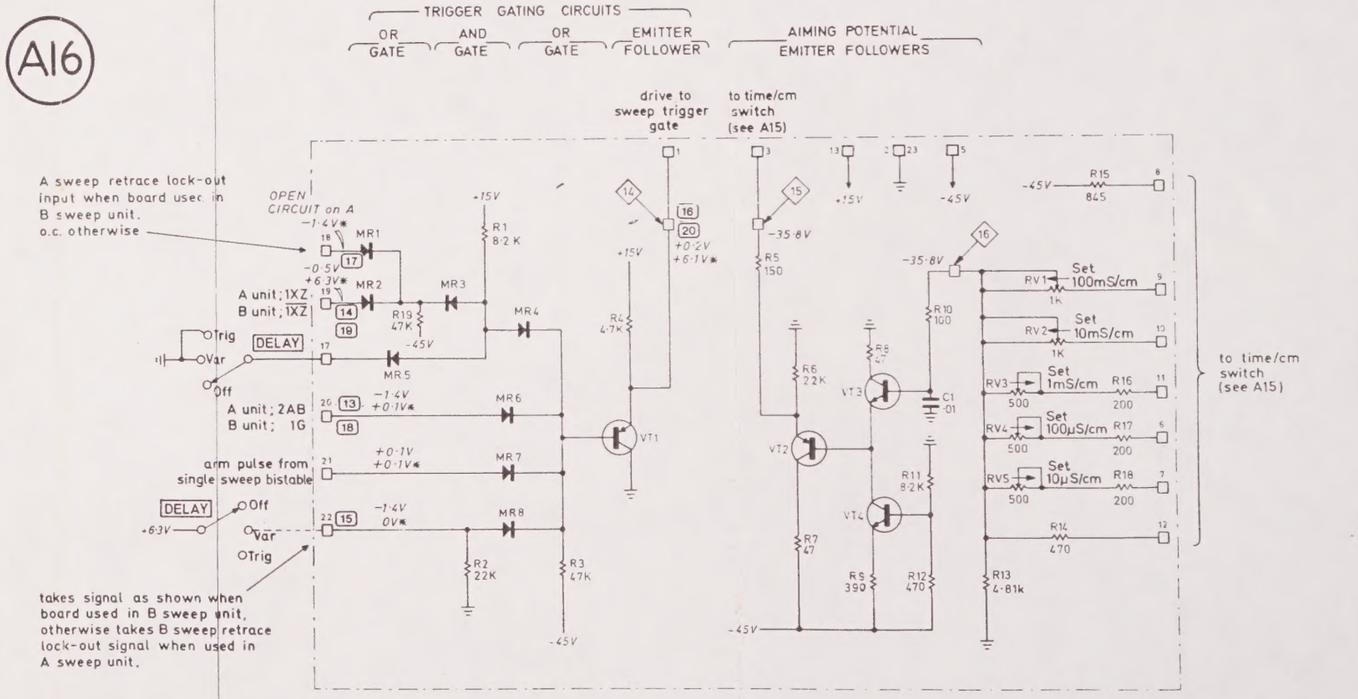
A16 (B unit) Pin 20



Set DELAY switch to TRIG
A16 (B unit) Test point 14

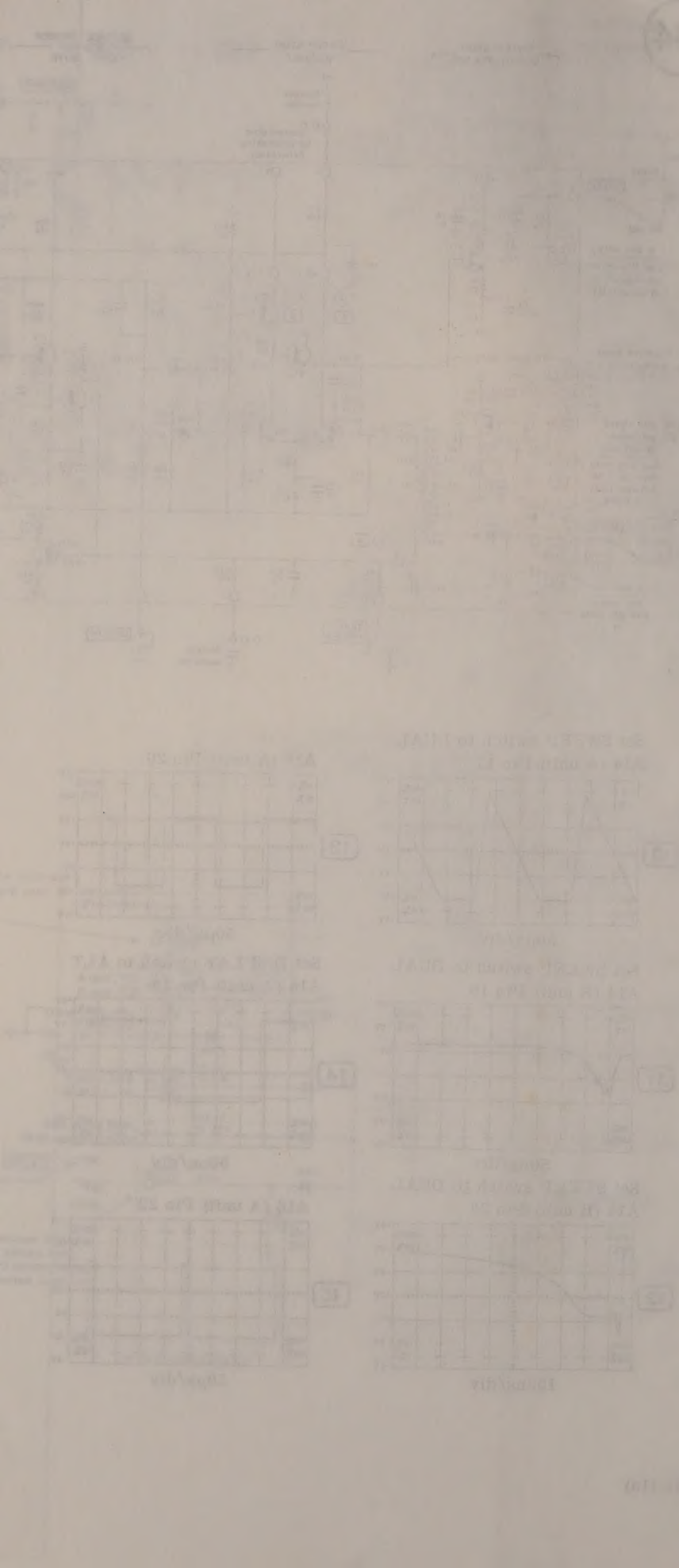


A16


TRIGGER GATING CIRCUITS
OR GATE
AND GATE
OR GATE
EMITTER FOLLOWER
AIMING POTENTIAL EMITTER FOLLOWERS
drive to sweep trigger gate
to time/cm switch (see A15)
A sweep retrace lock-out input when board used in B sweep unit. o.c. otherwise
OPEN CIRCUIT on A
A unit; 1XZ
B unit; 1XZ
Trig
DELAY
Var
Off
A unit; 2AB
B unit; 1G
arm pulse from single sweep bistable
takes signal as shown when board used in B sweep unit, otherwise takes B sweep retrace lock-out signal when used in A sweep unit.
Set 100mS/cm
Set 10mS/cm
Set 1mS/cm
Set 100µS/cm
Set 10µS/cm
to time/cm switch (see A15)

* B sweep voltages

Fig. 7.12 A14 : A16 Sweep and trigger gate circuits



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